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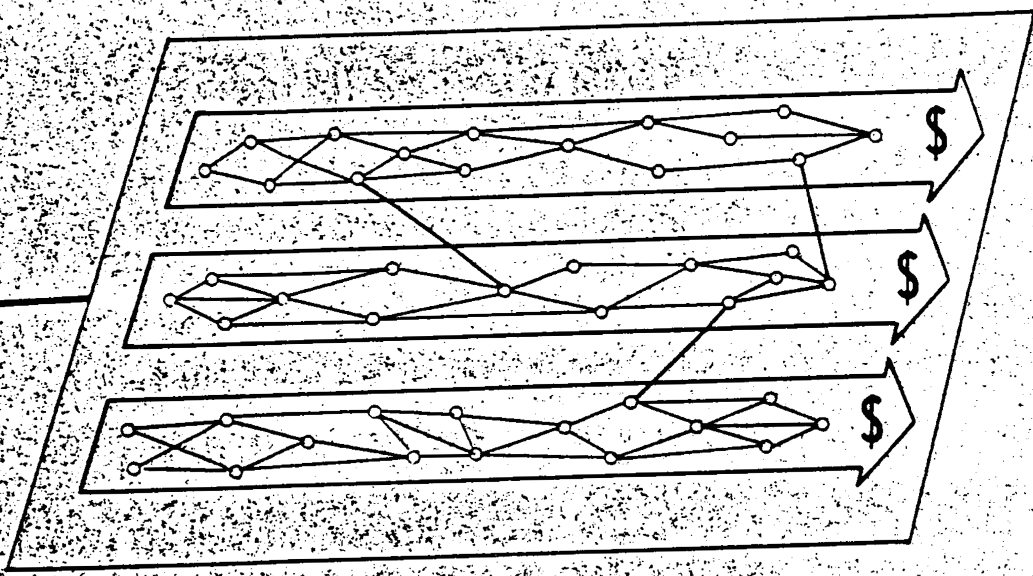
NASA PERT AND COMPANION COST SYSTEM



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HANDBOOK

U.S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. OFFICE OF PROGRAMS.

Foreword

The NASA system for project management described in this handbook is called NASA PERT and Companion Cost. This is an updating of the NASA system for project planning, evaluation, and control described in the NASA PERT Handbook first published in September 1961 under NASA Management Instruction 4-1-5. A draft version of NASA PERT and Companion Cost was published in June 1962 which served two purposes—(1), to formalize an integrated systems description of what was already being installed on many NASA projects using the NASA PERT time system plus the Contractor Financial Management Report (Form 533), and, (2), to furnish a comment edition to NASA users and their industrial counterparts. Although serving the latter purpose has delayed publication of this document, the time was well spent to incorporate the many helpful comments and criticism received from NASA personnel, other government agencies, individual industrial firms, trade associations and others into this edition.

The NASA PERT and Companion Cost system has been designed as a total management system concept. It is a practical system for total project management which utilizes the normal existing NASA management and administrative tools and processes, integrating them into a disciplined planning, control and reporting instrument for the project manager. The system design is relatively straightforward, contains a minimum of complexity and does not require more effort to use than any good planning and control system. However, it will not work for its intended purposes unless it is truly adopted by the project manager and his staff as the primary instrument for instilling discipline and validity into project planning, control and reporting. This is true even though the use of NASA PERT and Companion Cost is required on certain projects by the Associate Administrator, unless, program, project, staff, and supporting personnel both at headquarters and in the field have a full understanding of the system and the benefits which will accrue to all facets of management through its use. For this reason the Office of Management Reports, during the Fall and Winter of 1962-'63, will sponsor intensive orientation and training courses for all NASA personnel regardless of station so that the total understanding required may be obtained. These courses will be held at times and places designed to provide an atmosphere conducive to thorough training but with a minimum disruption to normal pursuits.

The basic theme of NASA PERT and Companion Cost is that total project management can be achieved only if the three management variables, TIME, RESOURCES, and PERFORMANCE, are managed and manipulated on a common framework which classifies all work elements of the project beginning from the top and shredding out the successive tiers representing systems, subsystems, etc., which make up the project. This pyramidal management framework, the key to disciplined and integrated project management is called the project work breakdown structure. A second primary theme of NASA PERT and Companion Cost is that this management structure must be developed and used from "cradle to grave" for a project. The work breakdown structure, in gross terms, should be established when the idea for the project is first conceived and continually refined throughout the life of the project so that at any instant in time there exists a common communicable management base for all project participants. Project progress in terms of time, resources, and performance is then evaluated against

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this base. Replanning and redirection, the dynamics which one always encounters in research and development can be accommodated by project management without allowing chaos to eventually permeate the project.

The careful reader will observe that the basic idea on cost correlation contained in the original NASA PERT Handbook published in September 1961 has been brought to fruition in a year's time. Chapter VII of the previous edition described certain internal NASA management system elements which required establishment and further development before a workable NASA PERT system providing time and cost correlation was practicable of achievement. During the past year much of our effort has been directed to establishing and getting approval for these elements. Particularly the Contractor Financial Management Report (Form 533) and the Agency-Wide Coding Structure, the latter being the master work breakdown structure for NASA as a whole, are such key elements. These form basic parts of NASA PERT and Companion Cost and should be thoroughly understood in themselves by all management personnel.

For NASA's contractors, NASA PERT and Companion Cost provides the formal management link necessary for the integration of contractor effort into the total project. A basic feature of the system is that PERT/Time data is reported to NASA for processing. This relieves contractors of the necessity of delaying reporting until networks have been processed and shortens the report cycle so that the NASA project manager receives timely data. Similarly cost data and projections furnished on the Form 533 by contractors is management level date which can be reported soon after the contractor's monthly accounting cut-off date, again, in order to furnish the project manager with timely, if not penny-accurate information. The reporting forms used for time (577) and cost (533) as well as the total system they represent have been approved by the Bureau of the Budget and were designed for maximum utility with the cooperative participation of industrial associations representing NASA's contractor base such as the Aerospace Industries Association and others who make up the Advisory Council on Federal Reports. It should be noted that certain NASA internal documents referred to in this handbook such as the Agency-Wide Coding Structure are not required by contractors for them to be able to use NASA PERT and Companion Cost. Publications describing these internal NASA systems will not normally be made available to contractors.

For the past year, NASA and the DOD, later joined by other federal agencies such as AEC and FAA have been working for the establishment of a uniform approach to PERT and PERT COST. In June 1962 NASA and DOD jointly published the "DOD and NASA Guide PERT COST Systems Design," which describes the basic PERT COST system concept to be used by contractors when they are required to perform in-house management on government contracts using PERT COST. The DOD and NASA Guide, therefore, is a more detailed treatment of PERT COST for the performing unit level. NASA PERT and Companion Cost follows the uniform system concept but is primarily directed at the higher level of total project management by the NASA project manager. Therefore it can be said the Guide and this Handbook are two parts of the same system. Contractors are encouraged to adopt the NASA DOD system whether or not they are required to use it by the government. Copies of the Guide may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D.C., order #D 1.6/2:P94, at the nominal charge of 75¢ each.

To assure uniform and valid applications of NASA PERT and Companion Cost to projects, the Office of Management Reports in addition to providing intensive orientation and training in the system will continue to provide assistance to headquarters, field center, and contractor personnel as required on projects. In addition, assistance is available to program offices to establish the use of NASA PERT and Companion Cost concepts in total program planning and control.

Users of this Handbook and others interested in the subject of project planning and control are invited to submit comments and criticism on all aspects of the system to serve as a basis for future revised editions. Submit comments and requests for additional copies of this Handbook by referencing the title, NASA PERT and Companion Cost, and addressing:

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Washington 25, D.C.

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SECTION I

PURPOSE

A PROJECT MANAGEMENT TOOL

The NASA-PERT and Companion Cost System is an integrated time/cost management tool basically designed to serve the NASA Project Manager. At the same time this tool also provides the selected information flow necessary for project monitoring and coordination at higher levels of NASA management and project coordination among all participating organizations.

When used in accordance with this handbook, this system will assist the NASA project manager in accomplishing his responsibilities for:

- The coordination of project planning—by supplying a disciplined and logical methodology for developing and analyzing a project plan, its component parts, alternatives thereto, and the varying levels of resources associated with each.
- The assessment of project status—by bringing a high degree of visibility and objectivity to bear on both technical and related financial planning, their interrelationships, and any consequent status determination.
- Reprogramming as a result of technical difficulties or changes in scope, schedule, resources or policy—by permitting rapid incorporation of these changes into the plan and the display of their resources and/or schedule effect on the project.
- The coordination of progress data—by integrating multiple source progress information into a single, easily understood form which is then immediately compatible with financial data covering the same scope.

A PRE-CONTRACT PLANNING AID

The NASA-PERT and Companion Cost System is recommended for use by all levels of NASA management as an aid in the conceptual planning of a project. This feature also applies in cases where study contractors are utilized to amplify NASA concepts prior to proceeding with developmental contracts. When used in this manner the system assists in:

- Definitizing the total scope of proposed contract and identifying the individual tasks to be done, at an early date.
- Assessing the relative merits of alternative approaches.
- Identifying key decision points and the associated deadlines for these decisions.

- Determining funding requirements and the rate of funding buildup.
- Establishing the critical areas of an effort and testing the effects on these areas of additional resources or parallel efforts.
- Defining the tasks which must be started immediately.

A CONTRACT PROPOSAL EVALUATION AID

Requiring prospective contractors to support their proposals with PERT networks and resource estimates in accordance with this system provides an effective aid for the analysis and evaluation of proposals. It provides:

- A discipline which communicates the logic and reasonableness of the proposed time schedules and resource estimates.
- A common base or structure for comparison of time schedules and resource estimates submitted by the various prospective contractors.
- A reassessment of target dates and resource requirements for completing various phases of the project as estimated by NASA project planners prior to requesting proposals.

A CONTRACT NEGOTIATION AND MANAGEMENT AID

The type of definitive base for contract scope, schedules, and related resources provided through the use of the NASA-PERT and Companion Cost system, is essential to create factual and rational contract negotiations initially and, later, to assess changes in scope, schedules and/or related costs after the contract has been let and work is progressing.

PROVIDES PROJECT MASTER PLANS AND STATUS

The NASA-PERT and Companion Cost system provides for the establishment of Project Master Plans for both schedules and resources related to work content. The Project Master Plans effectively communicate the gross components or project work breakdown and serve as a vehicle for rapid communication of project status.

SECTION II

GENERAL DESCRIPTION

This general description of the NASA-PERT and Companion Cost System assumes that the reader is familiar with basic PERT concepts. If not, Appendix B, "Basic PERT Fundamentals", should be studied prior to reading this section. In general, the NASA-PERT and Companion Cost System is an adaptation of the well-established Navy PERT system which has been married to a unique and flexible cost reporting system. The principal difference between the basic PERT concepts and NASA-PERT concepts is that NASA-PERT uses a single time estimate for activities in the network whereas basic PERT uses a three time estimate system. Other differences are strictly in the manner of utilization of the system.

WORK BREAKDOWN CONCEPT

In any integrated time/cost management system, it is imperative that both cost and time are planned and controlled from a common framework or structure (see Fig. II-a) which defines the major areas of work effort and their interrelationships, and establishes a common framework for structuring of PERT networks and cost categories. A top-down approach is used in the development of the work breakdown structure in order to ensure that the total project is fully planned and that all derivative plans contribute directly to the desired end objectives. A more detailed discussion of the development of a work breakdown structure is included in Section III.

NETWORKING CONCEPT

The NASA-PERT and Companion Cost System is designed primarily as a management tool for the NASA Project Manager in the field center. The nature of most NASA projects is such that the total project effort is represented by a combination of the efforts of several major contractors as well as a significant amount of NASA in-house effort. A primary responsibility of the NASA Project Manager is to integrate these efforts into a coordinated project plan, monitor and guide the execution of this plan, and provide redirection as required. Consequently, the NASA-PERT networking philosophy is that there will be one overall network for each project reflecting an integrated project plan which includes NASA in-house as well as contractor efforts.

The NASA project network is maintained, updated, and used as a management tool by the NASA Project Managers. Contractor responsibility in the operational phase of the system is primarily one of reporting against this NASA network. Other contractor responsibilities during the proposal phase and implementation phase as well as more specific responsibilities in the operational phase are elaborated in Sections V and VI.

WORK BREAKDOWN STRUCTURE

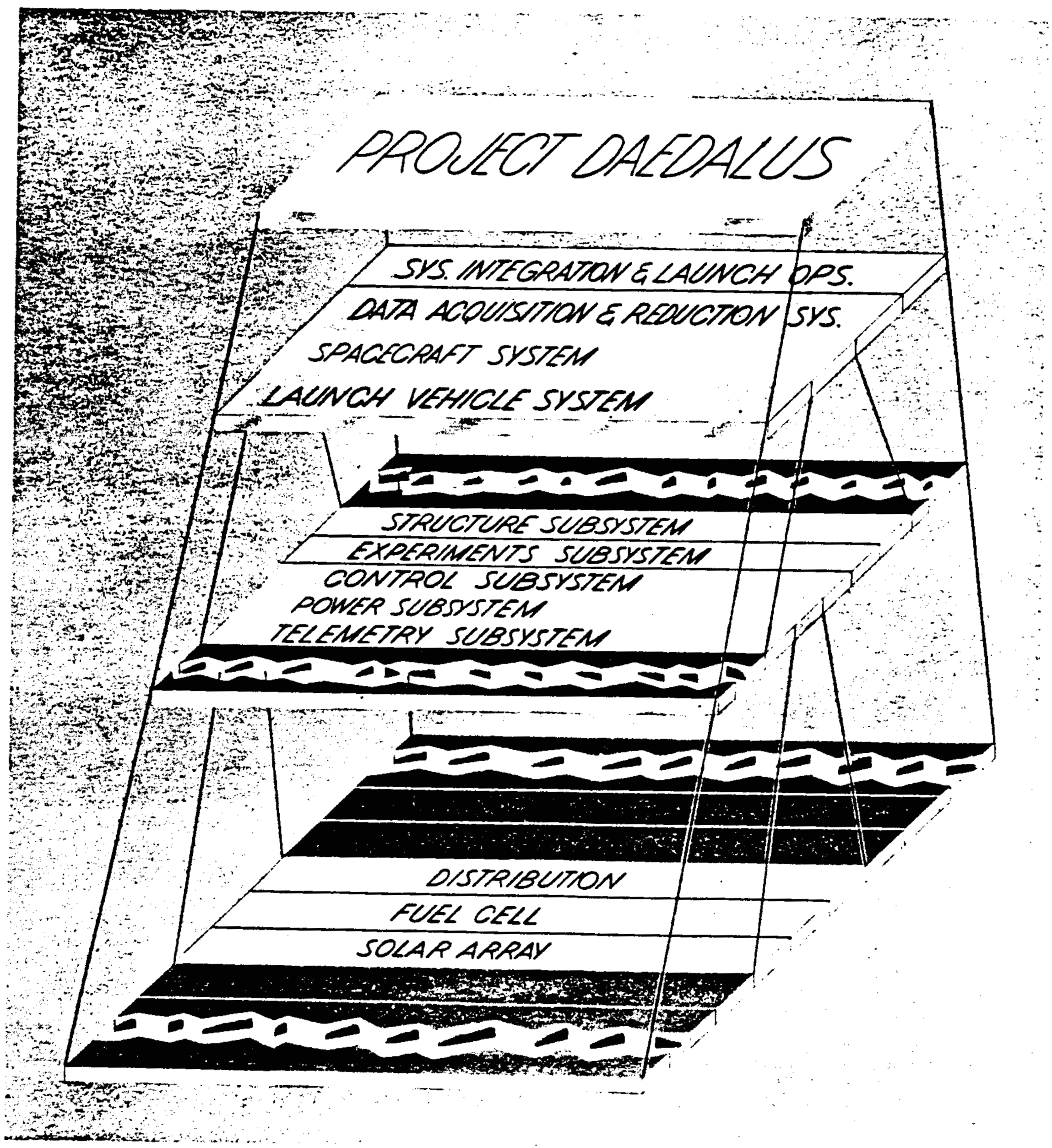

Fig. II-a

The level of detail in the NASA project network will not be sufficient for day to day management at the contractor level. The NASA project network should contain the minimum possible detail consistent with:

- providing for thorough and valid integration of the various contractor and NASA in-house efforts.

- providing for assessment of progress against plans in each of the respective contract and NASA in-house efforts to provide for "balancing of effort" by the project manager. By "balancing of effort" NASA will ensure that all areas of effort within a project are moving ahead at a properly balanced rate and that resources are not being unnecessarily expended in one area only to have that area wait, at a later time, for another to catch up.

- providing adequate detail to minimize ad hoc or special reporting in parallel with the PERT reporting.

In large projects, it becomes physically impractical to show the total NASA project on one piece of paper and it is broken down into several smaller portions called "fragnets" (see Fig. II-b) which are derived from the work breakdown structure as described in Section III. These fragnets are interconnected in such a way that data can be processed through the computer separately for each fragnet, for groups of fragnets representing a particular contractor's efforts or as a total project network. The relationship between fragnets is shown in a simplified manner on Fig. II-b. In actual practice there is a considerable amount of interweaving of contractor and in-house efforts which results in more interfaces than illustrated.

It should also be noted that structuring of the fragnets in accordance with the work breakdown structure illustrated in Fig. II-a, will result in "systems" oriented fragnets as opposed to "mission" oriented fragnets. For example, assume that our project DAEDALUS has five flight missions and that fragnets are established at the subsystem level. The control subsystem fragnet would then include all activities associated with the design, manufacture, test, and delivery of all five units of flight hardware. Activities associated with any development, prototype, or test models of the control system would also be included on this fragnet. When similar fragnets for all other subsystems are developed and interconnected as shown on Fig. II-b, the resultant Project Network will reflect an integrated plan for all five flight missions. This method of fragnet structuring has several significant advantages over "mission" oriented structuring, in which case separate fragnets are developed for each flight mission. These advantages are:

- Cost correlation is simplified.

- Total project integration is simplified.

- Network updating to reflect reallocation of hardware from one mission to another is simplified.

- Increased compatibility between fragnet structure and NASA organizational structure.

RELATIONSHIPS OF FRAGNETS TO NASA PROJECT NETWORK

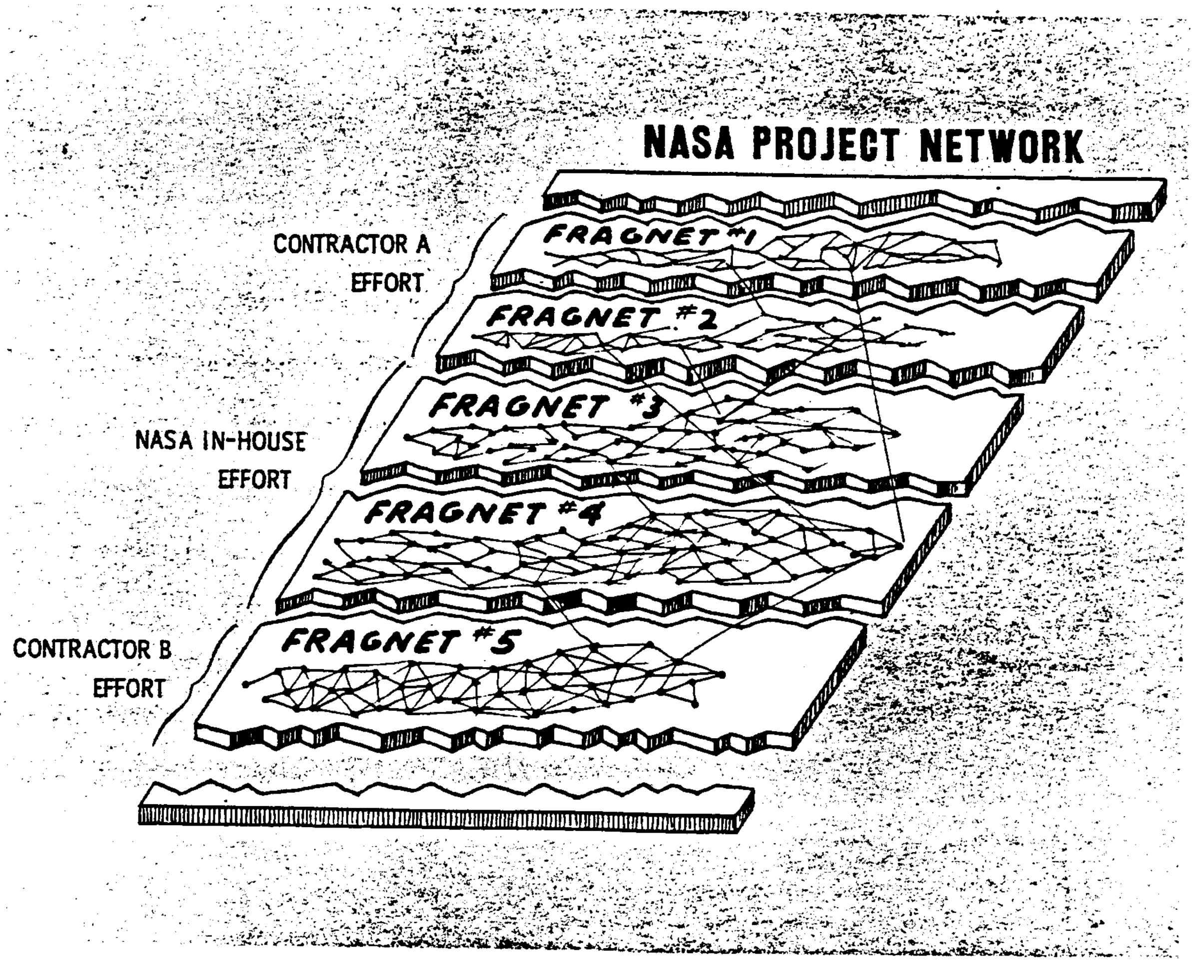

Fig. II - b

Cost and financial planning and reporting against "subdivisions of work" and "elements of cost" for total project effort includes, (1) data from contractors, and, (2) data on the NASA in-house work on the project. Both types of cost data are related to the common project work breakdown structure shown in Fig. II-a to obtain the total resources picture for the project and its "subdivisions of work."

Cost planning and reporting against the "subdivisions of work" and "elements of cost" categories is accomplished by contractors through a companion cost system called the NASA Contractor Reporting System described by NASA Management Instruction 6-2-4. This companion cost system for contract effort makes use of NASA Form 533 illustrated in Section VI.

Cost and financial planning and reporting against "subdivisions of work" for NASA in-house project effort is accomplished through NASA's internal resources programming and accounting system. Correlation of NASA internal cost and financial data with the project work breakdown structure is achieved through proper utilization of Appendix A of the NASA Agency-Wide Coding Structure.* The project work breakdown in Appendix A of the Coding Structure must, of course, be consistent and compatible with the project work breakdown structure formulated for project management using the NASA-PERT and Companion Cost system in order to achieve total cost correlation for the project "subdivisions of work." It is to be noted, however, that NASA in-house costs are relatively small compared to the magnitude of contractor cost on most projects requiring the use of NASA-PERT and Companion Cost. Therefore, the in-house costs, in general, need be identified only to the first, second, or third level breaks in the project work breakdown structure as appropriate in terms of magnitude and significance. Field Centers may and in most cases do sub-account costs for "subdivisions of work" at even lower levels of the project work breakdown structure and by other classifications such as internal organization to satisfy institutional management purposes. The same holds true for contractors.

This companion cost system for contractor and in-house project effort, as described above is:

- not limited to use with PERT but can be used by itself or in conjunction with any other NASA time-oriented management systems, such as line of balance, PMP milestone reporting, etc.

- compatible with existing NASA in-house and most contractor accounting systems as well as more recent sophisticated and detailed PERT/COST approaches.

- primarily a manual system until such time as more operational experience is gained and a unique NASA-PERT computer program including cost is developed.

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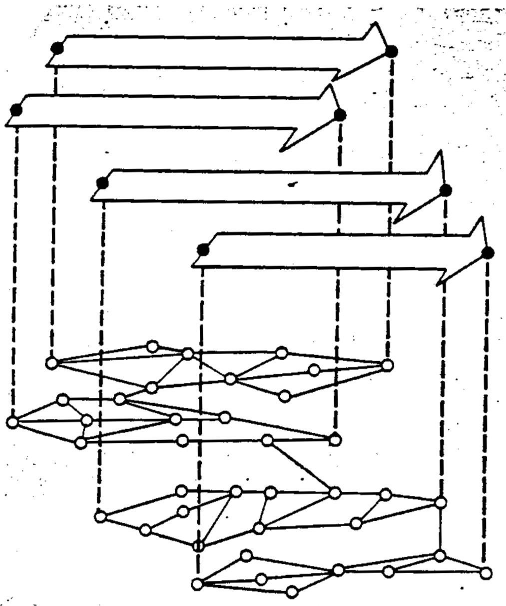
* Not necessary or available outside of NASA.

COST OVERLAY CONCEPT

Subdivision Of Work
Cost Categories



PERT Fragnets

Fig. II - c

The subdivision of work cost categories are then further divided into "elements of cost" as indicated in Fig. II-d.

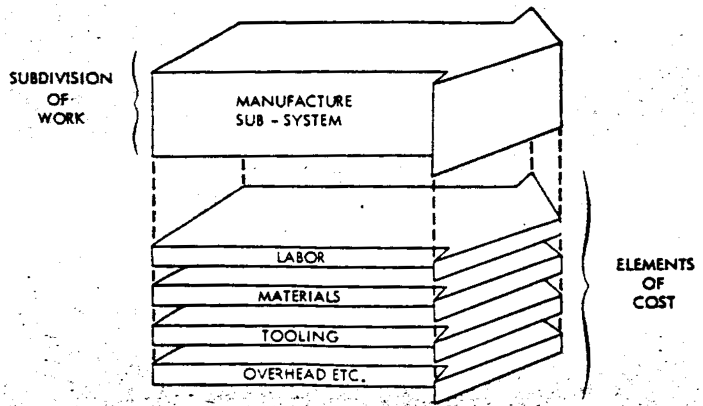


Fig. II-d

Even though the fragnet structure is "systems" oriented, several forms of "mission" oriented data can be obtained as computer outputs. For example, master schedules of key events leading up to launch of each individual mission can be generated. Also special computer runs which assume a specific mission as an end objective can be made and will identify all critical items leading to the launch of that mission. Both of these procedures and formats are described in more detail in Section VII.

As previously mentioned, the level of detail in the NASA project network will not be sufficient for day-to-day management at the contractor level. The input data reported against this NASA level network must be derived from a more detailed management system used by the contractor. This system could be a more detailed PERT system or any other good management system employed by the contractor. The decision as to whether the contractor will be required to use PERT for management at a lower level of detail than included in the NASA project network is left to the option of the NASA project manager. In general, it is encouraged that its adoption be voluntary on the part of the contractor rather than required by NASA. Although PERT has proved to be the most effective R&D project management system yet devised, it must be accepted and actually utilized for management at the contractor level, or it will not provide any better data than some other good management system voluntarily adopted and relied upon by the contractor.

MASTER PLAN CONCEPT

In the NASA-PERT and Companion Cost System master plans in the form of a master schedule and a master financial plan are used as a primary management control. These master plans are more summarized information than shown in the NASA-PERT project networks and 533 cost reports and become the framework against which project status is assessed. As the official project plans, they become a primary device for communication and coordination within NASA.

A more complete description of the master schedule and master cost plan is included in Section VIII.

COMPANION COST SYSTEM CONCEPTS

The work breakdown structure establishes the basis for correlating both actual and projected work progress and cost measurement. This correlation can be illustrated by a cost overlay concept as shown in a simplified manner in Fig. II-c. Cost categories for major work packages represented by individual fragnets or groups of activities on a fragnet are established. These major work packages cost categories are called "subdivisions of work" and are the basic unit for correlating financial data to the time plan represented on the corresponding portions of the project network.

RELATIONSHIP WITH NASA/DOD PERT/COST GUIDE

The NASA-PERT and Companion Cost System is a first step in the evolution of a completely integrated PERT/COST system. It provides for a correlation of time and cost at a much broader level of detail than commonly associated with so-called PERT/COST systems.

In the last few years, significant progress has been made by government and industry in the development of PERT/COST systems. However, the development effort has been proceeding on many fronts which has resulted in the generation of a large number of different PERT/COST approaches. To minimize the number of approaches being imposed on contractors by the government, NASA and the Department of Defense (DOD) have collaborated in the establishment of a set of general guidelines for the ultimate development of a uniform NASA/DOD PERT/COST system. These guidelines, "DOD and NASA Guide PERT COST Systems Design—June 1962," are primarily aimed at the development of a PERT/COST system at the contractor or performing unit level, and are directly in support of the NASA-PERT and Companion Cost System described in this handbook. A number of controlled experiments on selected projects are being established to further develop these principles, and to establish procedures and documentation for the integration of this type of contractor PERT/COST system with the NASA-PERT and Companion Cost System described in this handbook. NASA policy does not require general implementation of a detailed PERT/COST system until further experience has been gained through the controlled experiments and the procedures have been documented in a subsequent revision of the Guide.

SUMMARY—BASIC CONCEPT OF NASA-PERT AND COMPANION COST

This general description of the NASA-PERT and Companion Cost system concepts has described the establishment of a common framework or base for integrated cost and schedule planning and control. Once this base has been established and information flow initiated, the utilization of this data for planning, evaluation and control becomes a matter of prescribing formats and procedures for the presentation and analysis of this data. These formats and procedures are discussed in detail in Section IX.

SECTION III

DEVELOPMENT OF THE WORK BREAKDOWN STRUCTURE

As previously indicated, the purpose of the work breakdown structure is to provide a common framework for all aspects of project management, including the structuring of PERT fragnets and corresponding cost reporting categories. The development of a work breakdown structure starts from the highest level of management and progressively breaks down into smaller and smaller work packages to the desired control level. In NASA, the primary unit of control is a project (i.e., TIROS, ECHO, MERCURY, etc.) and NASA-PERT is designed as a management tool for the decentralized project managers in the NASA field centers. Therefore, the discussion and examples of a work breakdown structure in this section will start at the project level. A higher level program structure based on overall NASA management philosophy, organization, and budgeting is included in the Agency-Wide Coding Structure but is not germane to this discussion.

Standard units for breakdown of work below the project level are system, subsystem, task and subtask, respectively. As indicated in the example illustrated in Fig. II-a, the project is first broken down into its major systems such as launch vehicle, spacecraft, data acquisition and reduction system, systems integration, and launch operations, etc. A system such as the spacecraft is then subdivided into major subsystems such as structure subsystem, control subsystem, power subsystem, telemetry subsystem, etc. The work breakdown continues to successively lower levels, reducing the scope, complexity and dollar value at each level until a manageable unit for planning and control purposes is reached. The example shown in Fig. II-a is intended only to be illustrative, the actual configuration of the work breakdown structure, content, and level of detail will vary from project to project depending on:

- complexity and time span of the project
- estimated cost of the project
- NASA project management structure
- number of contracts and their relationships
- contractor/in-house relationships
- contractor's organization

The work breakdown subdivisions illustrated on Fig. II-a are defined as "end item subdivisions". They represent the hardware, services, equipment or facilities that are deliverable to the government or performed in-house. In effect, they represent progressive horizontal slices through the total project package. The next logical subdivision is to divide each of these end item subdivisions into functional phases such as design, manufacturing, test, etc., which can generally be represented as vertical slices through the end item subdivisions. This horizontal and vertical subdivision of the total project package can be visualized as a matrix as illustrated in Fig. III-a. The work effort represented within the boundaries of the horizontal and vertical grids are defined as functional work packages. However, it must be recognized that in actual practice the subdivision of a total project package into functional work packages is much more complex than illustrated in Fig. III-a. For example, not all end item subdivisions are hardware oriented (i.e: Systems Integration) and consequently the functional phases may not all be applicable. Therefore, each square defined by the grid is not necessarily a functional work package.

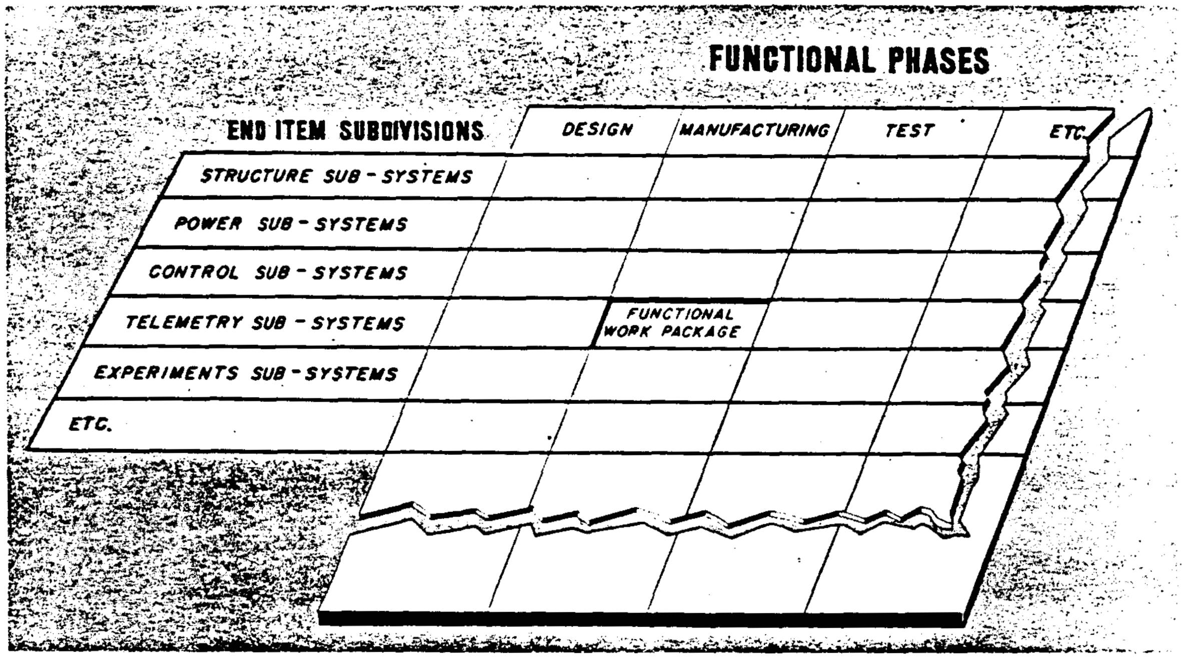


Fig. III - a

Determination of the level within the work breakdown structure at which fragnets are established and PERT and companion financial reporting from the contractor will be required is discussed in succeeding paragraphs. The work packages at the selected level, regardless of whether they represent end item subdivisions at the system, subsystem, task or subtask level or whether they represent functional work packages within the end item subdivisions, are defined as "subdivisions of work" for purposes of cost reporting on NASA Form 533. This should not be interpreted to mean that subdivisions of work must be established at the end item subdivision level for some areas of the project effort and at the functional work package level for other areas.

SECTION IV

FRAGNET AND COST CATEGORY DETERMINATION

LEVEL OF DETAIL

Determining the level of detail for the structuring of PERT fragnets and the corresponding cost categories is primarily a function of the size and complexity of the project and the "state of the art" of PERT/COST systems development and implementation. As indicated in Section II, the NASA Companion Cost system is at the present time primarily a manual system and, therefore, limits the practical level to which cost reporting can be established. Although it is desirable to establish cost reporting and control at the functional work package level, it is not generally recommended until such time as a NASA computer program for handling this cost data is established or the particular contractor has established a detailed PERT/COST system for his own in-house management as outlined in the "DOD and NASA Guide PERT COST Systems Design" dated June 1962. This does not preclude going to the functional work package level if warranted for a particular application; and in any case, the work breakdown structure is developed in a manner that will permit going to the functional work package level at a future date.

Due to the broad scope of the overall NASA program, there is a wide variation in the scope and nature of the various projects. Consequently, it is extremely difficult to prescribe a formula or procedure for determination of the fragnet and subdivision of work structure which would be valid for all projects. The general level of structuring desired can best be illustrated by discussing the minimum acceptable level of time/cost correlation that would apply for relatively simple projects with a low dollar value ($5 million or less) and progressively describing more sophisticated extensions together with some guidelines to assist in the determination of the level of detail for a given project. The actual determination of the level for a specific project is made in accordance with the implementation procedures outlined in Section V. During contract negotiations with the selected contractor, the cognizant NASA personnel will reach a clear understanding with the contractor on the general level of reporting that will be required. Final determination of the level is by NASA after giving due consideration to contractor inputs.

MINIMUM LEVEL OF TIME/COST CORRELATION

The minimum acceptable level of time/cost correlation for any project is to establish fragnets and subdivision of work cost accounts at the subsystem level. Using the example in the work breakdown structure in Fig. IV-a, a separate fragnet is established for the controls subsystem, power subsystem, telemetry subsystem, experiments subsystem, structure subsystem, etc., and a corresponding subdivision of work cost account is established for each of these subsystems as illustrated in Fig. IV-a. In this way, all the work effort associated with a particular subsystem, as reflected by activities on the subsystem fragnet, is charged to its corresponding subdivision of work cost account. Interface activities between fragnets must be identified as being charged to one of the two corresponding subdivision of work cost accounts. In general, the convention of charging to the account that the activity arrow comes from is recommended.

MINIMUM ACCEPTABLE TIME / COST CORRELATION

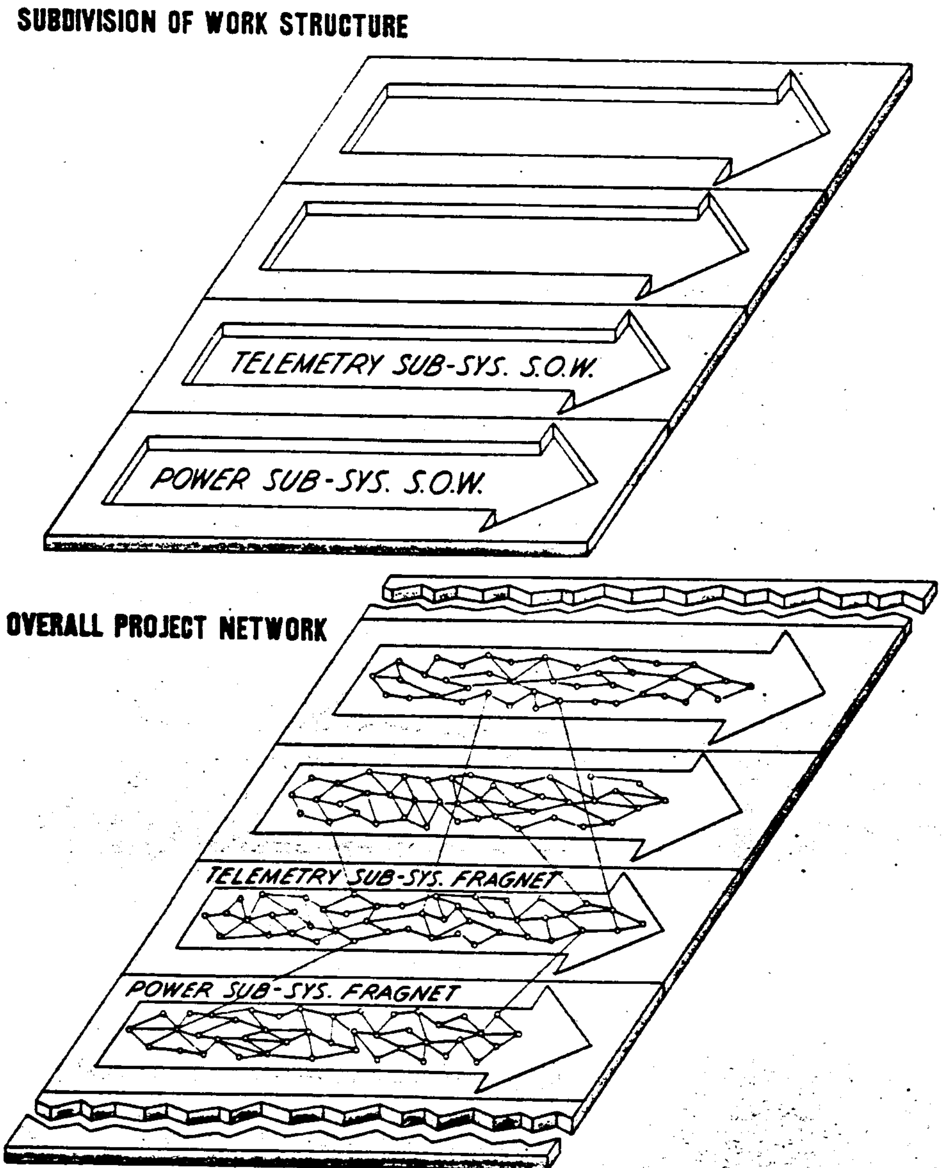


Fig. IV - a

The example shown in Fig. IV-a has assumed that there is a clear-cut division of contractor responsibilities at the system level. A single fragnet should always be limited to a single contractor's efforts. This does not mean, however, that a single contractor's efforts may not be shown on more than one fragnet. For example, in large contracts such as the Apollo Spacecraft, there may be 25-30 fragnets to show the systems contractor's efforts. The same groundrule applies to the subdivision of work. Consequently, the contracting structure is one of the most important considerations in the development of the work breakdown structure and the subsequent structuring of fragnets and subdivisions of work.

Assume the spacecraft system in our project DAEDALUS example represents the effort of a single contractor. Each of the subdivision of work cost categories is subdivided into elements of cost such as direct labor, materials, overhead, etc. This provides a two-way break cost structure for estimating and collecting costs as illustrated in an oversimplified manner in Fig. IV-b. Total contract dollars can be derived by summing the totals for all the subdivisions of work and adding fee as well as by summing the totals for all the elements of cost and adding the fee.

In assessing the feasibility of PERT/COST systems requirements in industry, NASA and the Department of Defense have found that most major firms and a significant percentage of the smaller firms included in the Space-Defense industrial base, have existing accounting systems with sufficient cost account identification capacity to provide reasonably detailed PERT/COST system applications. Space work is generally "systems" oriented. Firms whose accounting systems are organizationally and/or functionally oriented must provide "projectized" systems-oriented accounting within the functional-organizational breaks in order to provide accounting and estimating for subdivisions of work and elements of cost for the NASA system.

For projects somewhat larger in scope and dollar value, the next most logical break is to subdivide the effort shown on a particular subsystem fragnet into additional end item subdivisions as shown on Fig. IV-c. In this example, the power subsystem is subdivided into effort pertaining to the fuel cell, solar array and distribution. A separate subdivision of work cost category is established for each of these areas of effort even though the flow diagrams for all three may be drawn on the same fragnet. If the size of the fragnet becomes too large, it can then be broken down into three separate fragnets.

All of the subdivision of work breakdowns discussed up to this point have been end item subdivisions. For the most part, these subdivisions represent work packages which are horizontal slices through the total project effort and establish subdivision of work cost accounts that would be active for the major portion of the life of the project. There may be some time phasing of these accounts (in that design effort for some end items generally must precede that for others and operations type efforts will normally continue beyond that of others) but it would be very minor. Achievement of a significant amount of time phasing in the cost accounts is desirable in that it provides for a greater degree of time progress/cost correlation for assessment of progress in relation to accumulated costs and projecting cost estimates to completion of the project.

NASA PERT AND COMPANION COST

PROJECT DAEDALUS
SPACECRAFT SYSTEM - CONTRACTOR XYZ

SUBDIVISIONS OF WORK

ELEMENTS OF COST

POWER SUBSYSTEMS				$______
DIRECT LABOR	$______			
MATERIALS		$______		
OVERHEAD			$______	
CONTROL SUBSYSTEMS				$______
DIRECT LABOR	$______			
MATERIALS		$______		
OVERHEAD			$______	
ETC. ...				
FEE				$______
TOTAL CONTRACT (Adding Subdivisions)				$______
TOTAL DIRECT LABOR	$______			
TOTAL MATERIALS		$______		
TOTAL OVERHEAD			$______	
FEE				$______
TOTAL CONTRACT (Adding Elements)				$______

Fig. IV - b

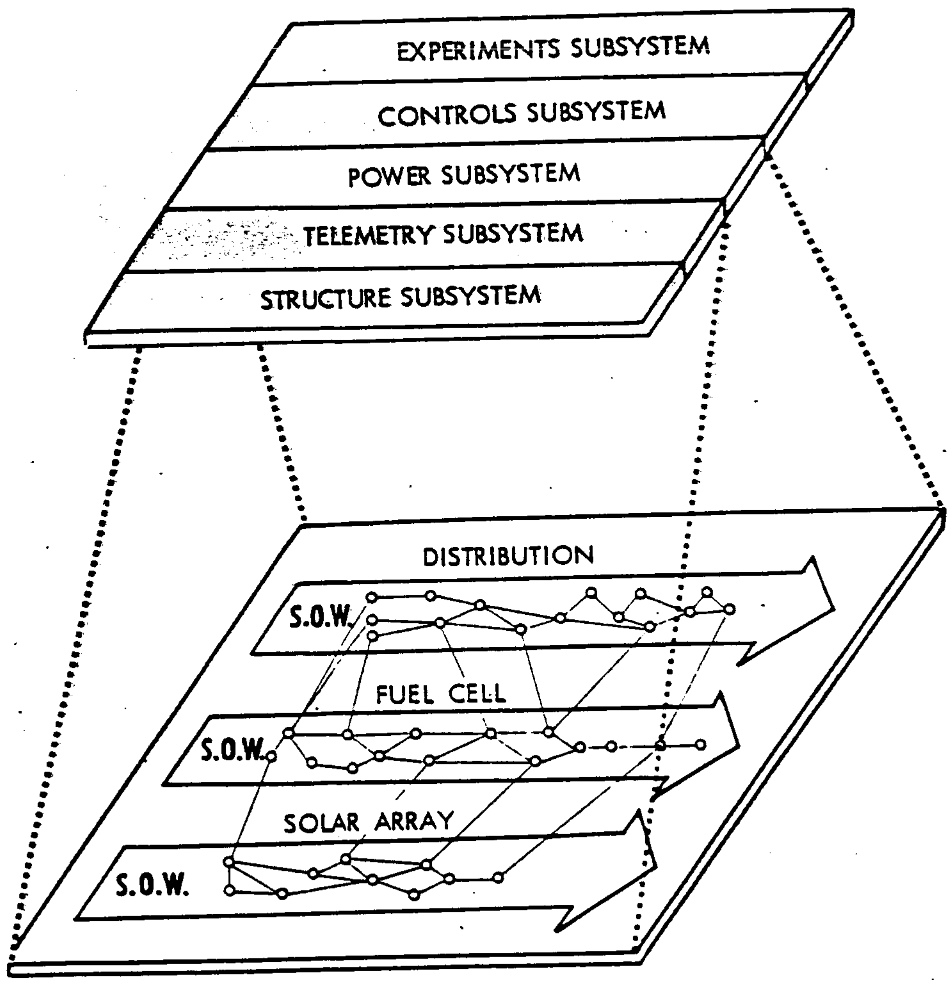

EXPERIMENTS SUBSYSTEM
CONTROLS SUBSYSTEM
POWER SUBSYSTEM
TELEMETRY SUBSYSTEM
STRUCTURE SUBSYSTEM
DISTRIBUTION
S.O.W.
FUEL CELL
S.O.W.
SOLAR ARRAY
S.O.W.

Fig. IV - c

MAXIMUM LEVEL OF TIME/COST CORRELATION

The maximum desired time/cost correlation would be to establish a subdivision of work cost account for each of the functional phases of each of the end item subdivisions. For example, a mechanical engineering subdivision of work cost account might be set up for the structure subsystem, one for the controls subsystem, etc. Similarly, subdivision of work cost accounts for electrical engineering, manufacturing, testing, tec., would be set up for each of the end item subdivisions as appropriate. Elements of cost within these subdivisions would be pure elements such as direct labor, materials, overhead, etc., as appropriate for the particular functional work package.

It can readily be seen that breaking down a medium to large size project to this level would result in a substantial number of cost accounts. Although this would provide a very desirable degree of time/cost correlation, the present Companion Cost System, on a manual basis, will not efficiently handle this level of detail.

Consequently, as previously mentioned, it is not recommended that a project be broken down to this level until such time as a NASA computer program for handling this cost data is established or the particular contractor has established a detailed PERT/COST system for his own in-house management as outlined in "DOD and NASA Guide PERT COST Systems Design - June 1962".

RECOMMENDED LEVEL OF TIME/COST CORRELATION

Implementation experience has indicated that a compromise level of time/cost correlation between the very broad end item subdivisions and the functional work package level is desirable. In this approach only the major phases of work effort which represent a significant dollar effort are selected as subdivisions of work. Fig. IV-d shows an oversimplified example of this approach. In large projects which involve a large number of subsystems the assembly of these subsystems into systems and the progressive checkout procedures are sufficiently complex to warrant establishment of a separate fragnet and subdivision of work cost account for this effort. Similarly, the test operations of the completed system and launch site operations can be broken out as individual subdivisions of work. On the other hand, each of the subsystems is not broken down into functional phases since this would increase the number of subdivisions of work to an unwieldy number.

This compromise approach reduces the total number of subdivision of work cost categories to a level where operation on a manual basis is feasible and yet allows the flexibility for further subdivision (if desired) at such time as a computer program is available.

GUIDELINES

The following guidelines are intended to provide some additional indication of the level of detail for the subdivision of work cost category structure. Like all guidelines and rules of thumb, they are necessarily general and not wholly applicable to all cases.

- It is expected that the total number of subdivisions of work may number anywhere from 10-15 on smaller projects to 150-200 on extremely large projects. More than 200 is recommended only on the largest of projects until such time as a NASA computer program is available.
- Dollar value of the subdivisions of work would generally be expected to range between $100 thousand and $5 million.
- Time span of the subdivisions of work would normally be expected to range between six months to the life of the contract.
- The number of NASA PERT activities charged to a specific subdivision of work could vary from 1 to 100 but are expected to average about 25 activities per subdivision.

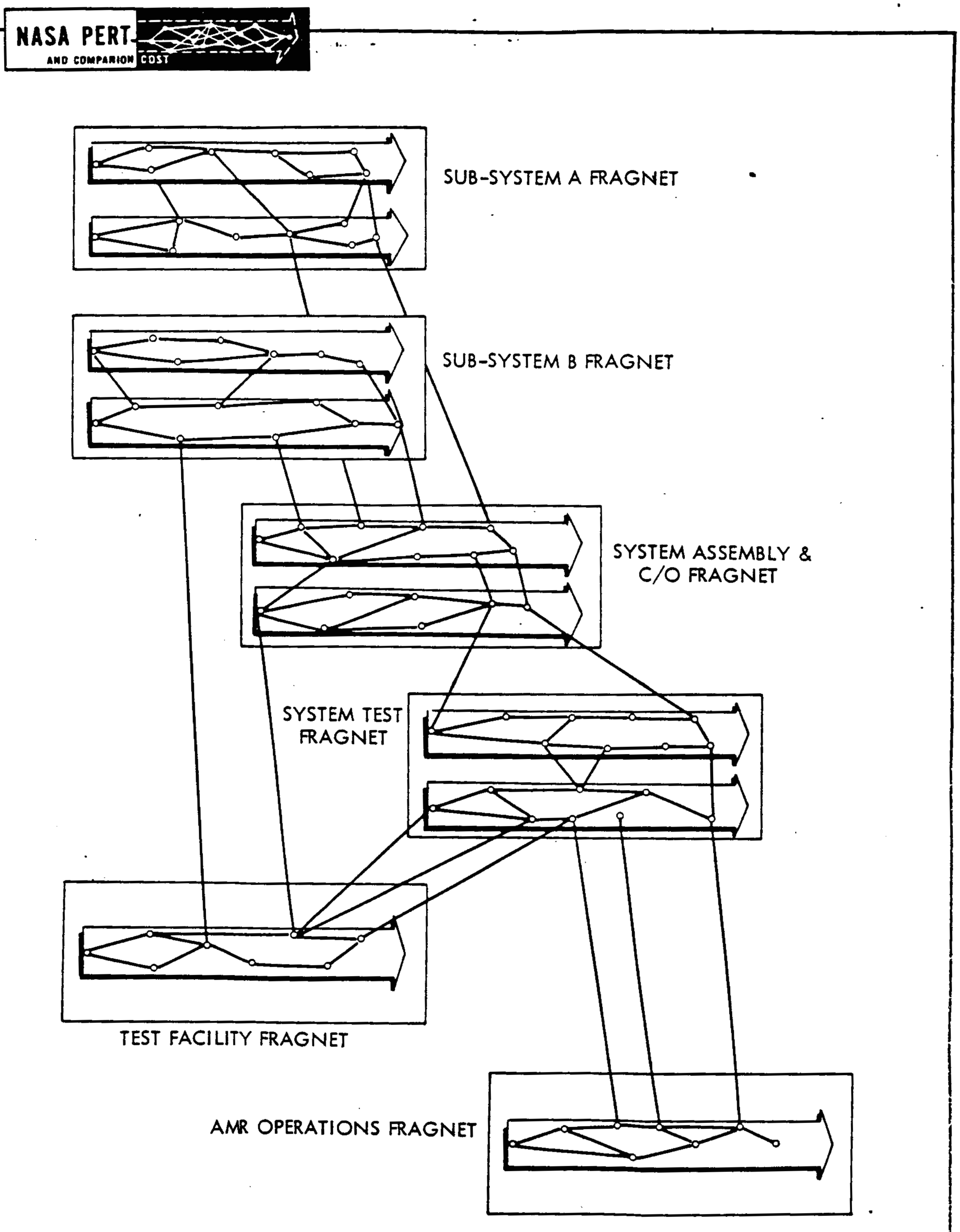

NASA PERT
AND COMPANION COST
SUB-SYSTEM A FRAGNET
SUB-SYSTEM B FRAGNET
SYSTEM ASSEMBLY & C/O FRAGNET
SYSTEM TEST FRAGNET
TEST FACILITY FRAGNET
AMR OPERATIONS FRAGNET

Fig. IV - d

SECTION V

IMPLEMENTATION PROCEDURES

The step-by-step implementation procedures described in this section are divided into four distinct phases; namely:

- NASA In-House Conceptual Planning Phase
- Proposal and Contract Negotiation Phase
- Implementation Phase
- Operational Phase

NASA IN-HOUSE CONCEPTUAL PLANNING PHASE

Step 1 — Determination of requirements for system implementation - Normally, the requirement for implementation of PERT and the Companion Cost System is established by the Associate Administrator at the time that a project is approved by the inclusion of the requirement in the project approval document. In addition, individual program managers in the Headquarters Program Office or the project managers at field centers may establish the requirement for use of the system even though it may not be required by the Associate Administrator.

Step 2 — Organizing for PERT — Prior to the implementation of the system it is necessary to establish a capability for implementing and using the system as a management tool at the respective field center.

Step 3 — Defining the project — Before using the system to aid in conceptual planning, it is necessary to define the objectives of the proposed project. It is necessary to begin structuring the various tasks that need to be accomplished in meeting this objective and listing various alternate approaches to meeting these objectives.

Step 4 — Develop a preliminary work breakdown structure - A preliminary work breakdown structure for each of the alternate approaches should be developed at the earliest possible time. This work breakdown structure serves as the framework for the development of planning networks and cost estimating.

Step 5 – Develop planning networks —Planning networks structured in accordance with the preliminary work breakdown structure are developed for each of the alternate approaches. These networks do not go to a very fine level of detail and, generally, will have activities which may be anywhere from three to six months duration. The primary purpose of these networks is to get a gross estimate of the overall time and effort required to meet the program objectives by each of the alternate approaches and then assess the relative merits of these approaches to eliminate those that are less attractive.

Step 6 – Establishing critical areas — The critical path concept serves to establish the critical areas or pace path in completion of the end objective. It also serves to identify the tasks which must be started immediately to minimize the overall time span for completion of the project.

Step 7 – Determining funding requirements —An initial master funding plan is developed. Using the work breakdown structure and PERT networks as a framework, cost estimates for each of the major tasks are estimated. Using the PERT networks to aid in cost estimating provides a better basis upon which to determine the rate of funding buildup. Generally, the estimates for funding the initial phases of a project are greater than can reasonably be utilized. The early phases of a project are generally planning and study efforts and the funding requirements are a function of the speed at which planning manpower can be mobilized. The critical path concept also focuses attention on planning efforts which must be started immediately and those which can afford to wait for some period of time.

Step 8 – Definitization of target dates and cost estimates — The networking and cost estimating cycles will normally be repeated several times in striving toward optimization of an overall project plan. Utilization of these techniques will serve to obtain a more realistic master schedule and estimate of resource requirements necessary to accomplish the project. The master schedule data which evolves should be included in the subsequent request for procurement as target dates to be used as a basis for contractor planning.

NOTE: Steps 4 through 8 are not always accomplished by NASA "in-house". If a contractor or team of contractors is selected to perform studies preparatory to hardware contracts, the activities outlined in these steps should be performed by that group.

PROPOSAL AND CONTRACTOR NEGOTIATIONS PHASE

Step 1 - Preparation of RFP— The RFP should include a requirement of prospective contractors to support their proposals with PERT networks and resource estimates in accordance with the procedures of this handbook. The target dates included in the master schedule as determined by the NASA in-house planning phase as well as the preliminary work breakdown structure should be included in the RFP as a guide for the development of the contractor proposal. If the RFP covers only a part of the total project effort, the applicable portions of the work breakdown structure and the master schedule should be clearly defined to prevent misunderstanding.

Step 2 - Evaluation of proposals—If the contractor proposal is required to be structured as indicated in step 1, the response to the RFP by the various contractors will provide an effective aid for the analysis and evaluation of bids. It provides:

(a) A common base or structure for comparison of time schedules and resource estimates submitted by the various contractors.

(b) A discipline which communicates the logic and reasonableness of the time schedules and resource estimates proposed by the various contractors.

(c) A reassessment of the target dates and resource estimates for completing various phases of the project as estimated by NASA project managers or study contractors prior to requesting bids.

Step 3 - Refine work breakdown structure—The additional information received in the proposals serves as a basis for further definitization and refinement of the work breakdown structure. It is important to make the refinement to the work breakdown structure prior to commencing with negotiations with the successful bidder. A relatively firm work breakdown structure should be on hand prior to commencing with negotiations in order to be able to negotiate from a position of strength and firm opinions of how the particular contractor's efforts fit into the total picture. If this definitization is not accomplished prior to negotiation, each contractor will be forced to develop its own work breakdown structure and NASA may find itself having to correlate and combine data from inconsistent and overlapping structures. Management confidence in data so derived must necessarily be limited.

Step 4 - Preliminary determination of fragnet work structure and level of detail of subdivisions of work cost accounts—A preliminary determination of the desired level of detail of time/cost reporting should also be made prior to commencing with negotiations. Determination of the level of detail will vary from project to project and will be made in accordance with the general guidelines included in Section III and IV.

Step 5 Negotiations - A clear understanding of the following items should be reached during negotiations with the successful bidder:

(a) The portion of the work breakdown structure which is that particular contractor's responsibility;

(b) The number of fragnets for that contractor's effort that will be developed and the approximate level of detail to be included in each of the fragnets;

(c) The level within the work breakdown structure at which subdivision of work cost reporting will be established, the approximate number of these accounts, and the elements of cost to be included within each of the subdivisions of work;

(d) A clear understanding of the contractor's responsibilities in the implementation of PERT and the Companion Cost System and responsibilities for reporting after the system becomes operational.

Step 6 — Contract Award — A standard contract clause is included in NASA procurement regulations and will be incorporated into all contracts for which contractor participation in the NASA PERT and Companion Cost system is required. This clause will include a time limit for the completion of implementation.

IMPLEMENTATION PHASE

Step 1 — Establish an implementation plan:

(a) Select an implementation team with representatives from the field center project office, centralized PERT office and the financial management office. Contractor members should be from similar functions. Assistance in implementation can also be obtained from the Office of Management Reports.

(b) Establish a series of implementation coordination meetings preferably at two-week intervals.

(c) Establish objectives to be accomplished at each of these meetings in accordance with the steps outlined below.

Step 2 — Establish interim progress reporting — As it may take from 3 to 6 months to fully implement the integrated PERT and Companion Cost system on large projects, a requirement for interim progress data exists. If the networks submitted with the selected contractor's proposal are grossly accurate, they may form the basis for an interim PERT reporting system. If they are not accurate, manual milestone reporting against the NASA master schedule is required until such time as the computer-processessed master schedules are available.

Step 3 — Establish interim financial reporting — Interim financial reporting is also established until such time as the complete system is operational. This interim reporting on NASA Form 533 is against subdivision of work and element of cost categories as selected by NASA after giving due consideration to the recommendations of the NASA/Contractor PERT implementation team. The structure of these interim subdivisions of work categories is compatible with the work breakdown structure and is not destroyed after completely integrated reporting is established. The final reporting will be a further breakdown of subdivision of work within the general category established for interim reporting.

Step 4 — Preliminary logic network development - Preliminary fragnets are developed for each of the respective areas of effort by the contractor and NASA implementation team. These preliminary fragnets show the logic relationships of the activities and do not necessarily include any time estimates. It should be possible to develop these networks in a relatively short period of time as a result of the networking efforts during the proposal phase and NASA in-house plan phase which were developed on similar structures.

Step 5 — Integration of logic networks — One by one the fragnets are integrated into a total NASA project network. As a result of this procedure, key interface events are established and the logic relationships of the fragnets are validated.

Step 6 — Selection of subdivisions of work for final reporting system — Once the logic networks have been integrated it is possible to go back and make the final break of the subdivisions of work within the general categories which were used for interim reporting. The network structure will assist in determining clearly identifiable and definable portions of the fragnet which can be grouped into a subdivision of work. At this point the decision must also be made whether these subdivisions will be further divided into functional work packages and to what level as described in Section III.

Step 7 — Refinement of logic networks — Using the key interface events established as a result of the network integration review, a further refinement of the fragnets is made to ensure proper integration of the total project network.

Step 8 — Establishment of time estimates — Time estimates for each of the activities on the fragnet are established by the contractor or organization having responsibility for the effort shown on that particular fragnet.

Step 9 — Initiation of contractor/PERT reporting — Computer input forms are prepared in accordance with procedures indicated in Section VI. These forms are prepared by the contractor and transmitted to the NASA field center by mail, TWX, or in the form of punched cards as mutually agreed by the PERT implementation team.

Step 10 — Initiation of contractor cost reporting — Reporting against the final breakdown of subdivision of work cost accounts is initiated in accordance with NASA Form 533 procedures.

Step 11 — Initiation of computer processing — Initiation of computer processing is generally a progressive procedure. As individual fragnets are completed and input data is received from contractors or "in-house" performing unit, they are integrated with each other in a progressive fashion until such time as the complete project network is programmed on the computer.

Step 12 - Assessment of computer output - Initial computer outputs tend to give a somewhat pessimistic outlook for completion of project objectives. This is due to the fact that initial network layout is based on an idealistic approach to accomplishment of the end objectives. However, time is not always provided for the execution of a project in the most ideal manner. Compromises must often be made and some risk assumed by doing certain things in parallel rather than in series. Evaluation of the initial computer outputs and resultant reprogramming of effort is one of the most significant steps in the overall PERT operation. It establishes the operational plan for getting the job done and becomes the basis for the definitization of schedule.

Step 13 - Definitization of schedules - After optimization of the project plan as described in step 12 above, a master schedule of key events is re-evaluated to reconfirm the validity of the schedule or to highlight unreasonable dates.

Step 14 - Approval of master schedule - The re-evaluation of schedules generally results in recommended changes to the project master schedule and when these affect the Official NASA Flight Schedule they must be submitted to Headquarters for approval.

Step 15. - Definitization and approval of master financial plan - Master financial plans initially developed during the NASA in-house planning phase will be continually adjusted and modified throughout the proposal and implementation phase as the project plans become more definitive. Master financial plans are definitized and approved at the same time that master schedules are approved. These approved plans then become the base for measurement and assessment of cost status.

OPERATIONAL PHASE

Step 1 - Contractor reporting - Contractor/PERT and financial reporting requirements are discussed in detail in Section VI.

Step 2 - NASA field center data processing - The detailed procedures for receiving data, preparing computer inputs, updating networks, computer processing, data analysis, and management action will vary from center to center depending on the organizational responsibilities established.

SECTION VI

CONTRACTOR REPORTING

GENERAL

During the operational phase of the NASA-PERT and Companion Cost System, the overall project network will normally be broken into fragnets and associated cost categories along the lines of the contractual structure. It is NASA policy that the contractor will then maintain the data included in the fragnets and associated cost categories which represent that part of the total project effort for which he is responsible, in a current and accurate condition. On the other hand, the NASA project manager will be responsible, during this phase, for computer processing of the fragnets, integration of the fragnets into a single project network, and overall correlation of time and cost data.

REPORTS

If a contractor is using PERT for in-house management or if NASA through its project manager has required a contractor to use PERT for management at a lower level of detail than the NASA project network, the reporting requirements outlined below may require modification. In such a case, the modification must receive the approval of the NASA project manager and field center before it can be implemented.

Contractor reporting of time data included on their respective fragnets is accomplished through the use of NASA Form 577. This form contains instructions for completing the required entries and the frequency of reporting. (See Figs. VI-a and VI-b) As a minimum acceptable report this form must list all activities whose expected date was passed during a given bi-weekly report period. To accomplish this, NASA should supply to the contractor a computer report covering the previous updating of his fragnet. The expected date sort from this report (Fig. VII-d) can then act as a check-off list to ensure a minimum acceptable report. In addition, such modifications in the network as may be necessary from time to time to indicate changes in plan should be included. As required, individual NASA project managers may request a written statement explaining the changes included therein, and an assessment of their effect on the fragnet objective(s).

A TWX substitute for Form 577 has been developed and the detailed description of format is included in Appendix C. This form of reporting should be used when directed by the NASA project manager. In addition, numerous other schemes are available for the rapid transmission of digital data. As a general rule any of the methods of reporting are acceptable as long as they meet the NASA reporting deadlines with accurate, valid information.

To report cost data on work subdivisions NASA Form 533 will be used. This form contains generally self-explanatory instructions about the data required and the frequency of reporting (see Figs. VI-c and VI-d). Should any questions arise they should be directed to the PERT implementation team.

NASA PERT AND COMPANION COST

NASA PERT AND COMPANION COST SYSTEM

ACTIVITY DATA REPORT

(A) NETWORK TITLE	PAGE OF PAGES	*Form Approved Budget Bureau No. 104-R009.1*
(B) FROM: (C) TO:	(D) START DATE	(F) CLASSIFICATION
	(E) REPORT DATE	(G) NETWORK NO.

CODE 1	M/S 2-3	PREDE-CESSOR EVENT 4-10	SUCCESSOR EVENT 11-17	TIME EST. 18-21	RE-SOURCE EST. 22-25	SCHEDULE OR ACTUAL 26-31	ACTIVITY DESCRIPTION 32-74	RE-SERVED 75-76	ORG 77-80

NASA FORM 577 (REV. JUL 62) PREVIOUS EDITIONS ARE OBSOLETE.

Fig. VI-a

INSTRUCTIONS FOR COMPLETING NASA FORM 577

General

NASA Form 577 will be prepared when directed by NASA Project Managers in accordance with the requirements of the NASA-PERT and Companion Cost System Handbook. Normally, reports will not require security classification; however, if necessary the appropriate classification should be shown in the space provided. This report should be prepared and submitted on alternate Fridays via mail, TWX, or phone, as required, to be received by the NASA Project Manager the following Monday morning. The data contained therein shall be current as of the reporting date.

Heading

(A) *Network title* - 60 alphabetic and numeric characters describing network.

(B) *From* - Contractor or NASA "*in-house*" performing unit.

(C) *To* - NASA Project Manager, NASA Field Center.

(D) *Start Date* - this date gives the computer a base point from which to calculate other dates.

(E) *Report Date* - date of the latest revision.

(F) *Classification* - as appropriate.

Card Columns

(1) *Transaction Code* - this code tells the computer or key punch operator what action should be taken with the data following on that line.

- (1) - Establish new activity
- (2) - Reestimate activity
- (3) - Complete activity
- (5) - Delete activity

Card Columns *(Continued)*

(2-3) • *Master Schedule Flag* - two digit code which indicates on what master schedule an activity will be printed.

(4-10) *Predecessor* - seven digit number identifying event preceding an activity.

(11-17) *Successor* - seven digit number identifying event preceding an activity.

(18-21)• *Time Estimate* - in weeks and tenths of weeks.

(22-25)• *Resource Estimate* - reserved for future use as resource correlation columns.

(26-31)• *Schedule or Actual* - six digit schedule or actual date.

(32-74) *Activity Description* - up to 43 alphabetic and/or numeric characters can be used to describe the activity.

(75-76) *Reserved* - for NASA use only

(77-80) *Organization* - four alphabetic and/or numeric characters can be used for a coded identification of responsibility for activity accomplishment.

NOTE: *If this report is to be used as the source for key punching computer cards and no significant data is posted in the columns marked (*), an appropriate number of zeros should be entered therein.*

Fig. VI-b

(12) CONTRACTOR'S REMARKS

(13) SIGNATURE AND DATE

INSTRUCTIONS FOR COMPLETING NASA FORM 533

General. NASA Form 533 will be prepared when directed by contracting officers in accordance with the requirements of the contract. Forms will be obtained from the contracting officer. Normally the reports will not require security classification. However, if any of the information in the report is classified, appropriate classification will be given the report.

Submission. Quarterly reports submitted for both (1) subdivisions of work and (2) elements of costs will have all columns completed. Monthly reports, unless otherwise required by the contracting officer, will be limited to subdivisions of work and will only use items 1 through 8, 9a (1) and (2), and 9d(1). Columns 11a, b, and c will be completed if there is a change in dates. Monthly reports are due the 15th day and quarterly reports the 20th day after the end of the period being reported. Monthly reports will not be submitted for the last month of the quarter. The actual costs will be the most accurate available at the time of reporting.

1. Contract Description, Number and Type. Enter the type, i.e., cost-plus-fixed-fee, and complete letter or contract symbol and number; include any letter identification as shown in the contractual document being reported. Enter the number of the latest amendment, if applicable. Include a brief identification of the contract items or services being procured.

costs will be used for reporting purposes only and will not be binding on either the contractor or the Government.)

(1) During Reporting Period. Enter the costs for the month if a monthly report or the total of three months if a quarterly report.

(2) To Date. Enter the total costs of the contract, through the end of the reporting period.

b. Estimated Costs to Completion. Enter the appropriate quarter and fiscal year designations in the Column headings. Enter the estimated costs to be incurred during each projected period. These entries will not be cumulative. They will be forecasts for each of the next five quarters; balance of the fiscal year (1, 2, 3, or 0 quarters); next fiscal year and balance of the contract to completion thereafter. The total of the estimated costs of completion is the total of Columns 9b(1) through 9b(8).

c. Grand Total. Enter the total estimated costs to be incurred during the life of the contract. The amount is a total of Columns 9a(2) and 9b(9).

d. Unfilled Orders Outstanding. Enter the appropriate quarter and fiscal year designations coinciding with 9b. Enter the total of unfilled orders outstanding as of the end of the periods indicated. For the purpose of this report, unfilled orders are defined as an incurrence of a identification as shown in the contractual document being reported. Enter the number of the latest amendment, if applicable. Include a brief identification of the contract items or services being procured.

2. To. Enter the name of the NASA field installation and the name of the contracting officer to whom the report is submitted.
3. From. Enter full name and address of contractor and, if applicable, the contractor's division performing the contract.
4. The following will be completed only on the first sheet of each report:
   a. Contract Value. Enter the total estimated cost plus fixed-fee of all work to be performed under the contract including amendments. Include only those contract change notices that have been formalized.
   b. Contract Ceiling. Enter the funding to date of the contract (as amended).
   c. Invoice Amounts Billed. Enter the total amounts of invoices billed by the contractor against the contract.
   d. Total Payments Received. Enter the total amounts of payments received by the contractor for this contract.
5. Report for Month or Quarter Ending. Check the block indicating the period involved, month or quarter, and enter the ending date of the period.
6. Sheet --- of ---. Enter the number of the sheet and indicate total number of sheets submitted for all parts of the report.
7. Item No. Identify each line item by number and letter, as appropriate.
8. Subdivisions of Work and/or Elements of Cost. Separate reports, with reportable detail determined on an individual contract basis, will be submitted for:
   a. Subdivisions of Work. Enter a short description of each subdivision of work. Include a total of all subdivisions for the contract total showing the fixed fee as one line item.
   b. Elements of Cost. Show each subdivision of work and enter thereunder the elements of cost such as direct labor, materials, overhead, subcontracting, tooling, etc. Include a summary by cost elements for the total contract showing the fixed fee as one line item.
9. Total Contractor Effort.
   a. Costs. Costs are defined as costs of goods and services used to accomplish the assigned work regardless of when received or paid. Inventories which are reimbursable under the terms of the contract but not yet costed to subdivisions of work will be shown as a separate line item. (These inciding with 9b. Enter the total of unfilled orders outstanding as of the end of the periods indicated. For the purpose of this report, unfilled orders are defined as an incurrence of a firm obligation by the contractor, such as subcontracts, purchase orders and similar items which have not become costs.
10. Costs of Completion.
    a. Last Report. Enter the amount as indicated in Column 10b of the last report.
    b. This Report. Enter the updated estimate of the total cost to NASA for completion of the contractual task. This estimate should reflect at the time of the report, any foreseeable increases or decreases in the contract value or ceiling entered in Item 4. The estimated report will be used for planning purposes only and will not be binding on either the contractor or the Government. This is the same as Column 9c.
    c. Amount Change (Plus or Minus). Enter the difference between Column 10a and 10b. Give a brief but complete explanation of the need for any increase or the means of achieving a decrease in the space provided for in Item 12 on the reverse of the form. This entry shall be made even though separate requests for such a change have been previously submitted by the contractor.
11. Completion Date. Complete quarterly for subdivisions of work or monthly if there is a change in dates.
    a. Last Report. Enter completion date as shown in Column 11b of the last report submitted.
    b. This Report. Enter the estimated date on which contractor performance will be completed. This entry shall not serve as a notice to the Government of late delivery nor as acquiescence in such late delivery by the Government.
    c. Change. Enter the difference between Columns 11a and 11b by weeks. Enter a brief comment of why a change in time phasing has taken place and how the time phase affects the previously submitte time phasing schedule of the total contractual assignment. If additional time is required, include an explanation of what means would be necessary to restore the schedule for the completion of the contract. If acceleration has been indicated, include a statement explaining the factors which led to a decrease in time phasing.
12. Contractor's Remarks. Enter explanations relating to changes in amounts in Column 10c and changes in time in Column 11c and any other comments considered appropriate.
13. Signature and Date. The authorized contractor representative will sign and date the report.

FIG. VI - c

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACTOR FINANCIAL MANAGEMENT REPORT

(All figures in thousands of dollars)

1. CONTRACT DESCRIPTION, NUMBER, AND TYPE

2. TO:

3. FROM:

TOTAL CONTR

7. ITEM NO.	8. SUBDIVISIONS OF WORK AND/OR ELEMENTS OF COST	9. a. COSTS		b. ESTIMATED COSTS OF COMPLETION							
		DURING RPTG PD. (1)	TO DATE (2)	QTR (1)	QTR (2)	QTR (3)	QTR (4)	QTR (5)	BAL. OF F.Y. ____ (6)	NEXT F.Y. ____ (7)	BAL. OF CONTRACT (8)

Face blank p. VI-4)

4a. CONTRACT VALUE $

4b. CONTRACT CEILING $

4c. INVOICE AMOUNTS BILLED $

4d. TOTAL PAYMENTS RECEIVED $

BUDGET BUREAU NO. 104-R011
APPROVAL EXPIRES DECEMBER 31, 1963

5. REPORT FOR ☐ MONTH OR ☐ QUARTER ENDING

6. SHEET OF SHEETS

RACTOR EFFORT

	c.	d. UNFILLED ORDERS OUTSTANDING								10. COSTS AT COMPLETION			11. COMPLETION DATE		
TOTAL (9)	GRAND TOTAL	END OF RPTG. PD. (1)	QTR (2)	QTR (3)	QTR (4)	QTR (5)	QTR (6)	END OF F.Y.____ (7)	END OF NEXT F.Y.____ (8)	LAST REPORT a	THIS REPORT b	AMT. CHANGE + OR (−) c	LAST REPORT a	THIS REPORT b	CHANGE c

SECTION VII

COMPUTER PROCESSING & OUTPUTS

GENERAL

The NASA-PERT and Companion Cost System uses data processing equipment to process time and schedule data only. Companion Cost information from contractors is gathered and summarized manually. Therefore, discussion in succeeding paragraphs of this section will be limited to time aspects of the system.

COMPUTER PROGRAM

At present, the Lockheed-originated 7090 computer program or one of the three variations to it originated by the Langley Research Center, the Manned Spacecraft Center or the Hughes Aircraft Company are being used within NASA. The Langley Research Center and Manned Spacecraft Center variations are being merged into a single program which will become a standard NASA-PERT (time) program. This program will then be extended into a standard NASA-PERT and Companion Cost System program.

COMPUTER REPORTS

For purposes of illustrating the discussion contained in the following sections the NASA-PERT fragnet shown in Fig. VII-a was computer-processed by the Manned Spacecraft Center. Examples of the resultant computer reports are shown in Figs. VII-b through VII-f.

- Runs

  A single computer processing of a fragnet deck can produce up to 8 runs of 5 reports each. Run 1 which allows multiple terminal events calculates the latest allowable dates for an entire fragnet by using the most critical of these events. Runs 2 through 8 allow one to preselect up to 7 intermediate events as single terminal events and thus obtain latest allowable dates calculated on these objectives. Run 1 is always produced when a fragnet is submitted for processing; Run 2 through 8 (or any lesser number) are optional and require special arrangements with your processing center to obtain.

- Listing Within Run

  Within each run the activities are listed into five reports. The information listed for any given activity is basically the same in each report but the sorting of the activities varies.

- <u>Numerical Sorts</u>

At the present time, the computer program is designed to give as a standard report a numerical sort based primarily on the successor and secondarily on the predecessor event numbers. (See Fig. VII-b) This report is useful for determining information about an activity when the event number is known, e.g., when looking at a network without knowledge of path criticality or expected date.

- Various other types of numerical sorts can also be generated for special purposes. To accomplish this care must be exercised in the assignment of numbers to various events. Examples of special sorts which may be desired and obtained for the use of the project manager are:

(a) All events which are the responsibility of a particular organizational unit, contractor, system, subsystem, etc.

(b) All tasks chargeable to a particular cost accounting number.

(c) All activities requiring a common specialized production facility, test facility, launch pad, etc.

- <u>Paths of Criticality Sorts</u>

Another standard report generated is the slack sort. This report isolates the paths of criticality by sorting primarily on the slack column and secondarily on the expected date. (See Fig. VII-c) As a result, all activities with the greatest amount of negative slack are arranged in expected date order. This is the critical path. The computer then lists all activities with the second greatest amount of negative slack by expected date and this becomes the second most critical path. In like manner, the computer proceeds through the network listing all activities in their appropriate paths.

This report is most useful to the project manager in determining the areas requiring his attention and corrective action. If the time required to accomplish the list of critical activities is longer than the time available for their accomplishment as indicated by the schedule date of the objective event, either resequencing of the critical activities, reallocation of additional resources or relaxation of schedule is indicated. If action is taken that will shorten the critical path below the second most critical, it, in turn, becomes the overall project time control and in turn requires management attention. In like manner, this path is analyzed and appropriate management action applied until all paths of negative slack value are reduced to an economic minimum.

All previous discussion of the slack sort has assumed that the objective event had a constant schedule date to which its latest allowable date was equated. Against this, the expected date was compared to determine slack. This, however, is not always the case. When used in the early conceptual phases of a project a schedule date for the objective event may not have been defined. In this case the computer is instructed to set the latest allowable date for the objective event equal to the calculated expected date. The critical path will then have zero slack and all other paths will have positive slack values in respect to the critical path. This mode of operation may aid in the determination of a schedule.

- Time Sorts

As a standard report the computer program is designed to sort the network data on the basis of the expected date column. (See Fig. VII-d) This listing starts with the completed activities, then the work in progress, and finally the future activities required to achieve the end objective. Additional sorts can be made on the basis of the latest allowable date or the schedule date columns. These require special arrangements with your computing center.

The expected date report is designed to give the project manager a listing of recently completed activities and of work in process along with a measure of its relative criticality. As such it can become the basis of periodic program reviews between project, system and subsystem managers.

This report is also useful to those responsible for obtaining and initiating periodic computer updating reports. By listing all activities expected for completion between two report dates, it acts as a handy check-off list to ensure that no activity requiring updating is overlooked.

- Organizational Sort

Four alphabetic and/or numeric columns on the computer input form have been reserved for identifying organizations responsible for a given activity. This listing sorts primarily on these columns and secondarily on the expected date column. When printing this report, the computer switches to a new page for each organization indicated. (See Figs. VII-e through h) Such a listing has the obvious advantage of isolating for a given organizational element in a time-oriented list all activities for which it is responsible.

- Master Schedule Sort

The master schedule sort is a summarized listing of previously selected key events which are vital to success of a project and it, therefore, becomes a focal point for management attention. It contains the master milestones, the approved schedule date for accomplishing them and the outlook for meeting schedule as represented by the expected date (T_E), the latest allowable date (T_L) and slack. (See Fig. VII-i) This report has been event-oriented by the use of dummy activities and event nomenclature. In addition, a convention has been established that the first five spaces of the event nomenclature will be left blank. This highlights master milestones when they are combined with normal events. (For example see Fig. VII - j)

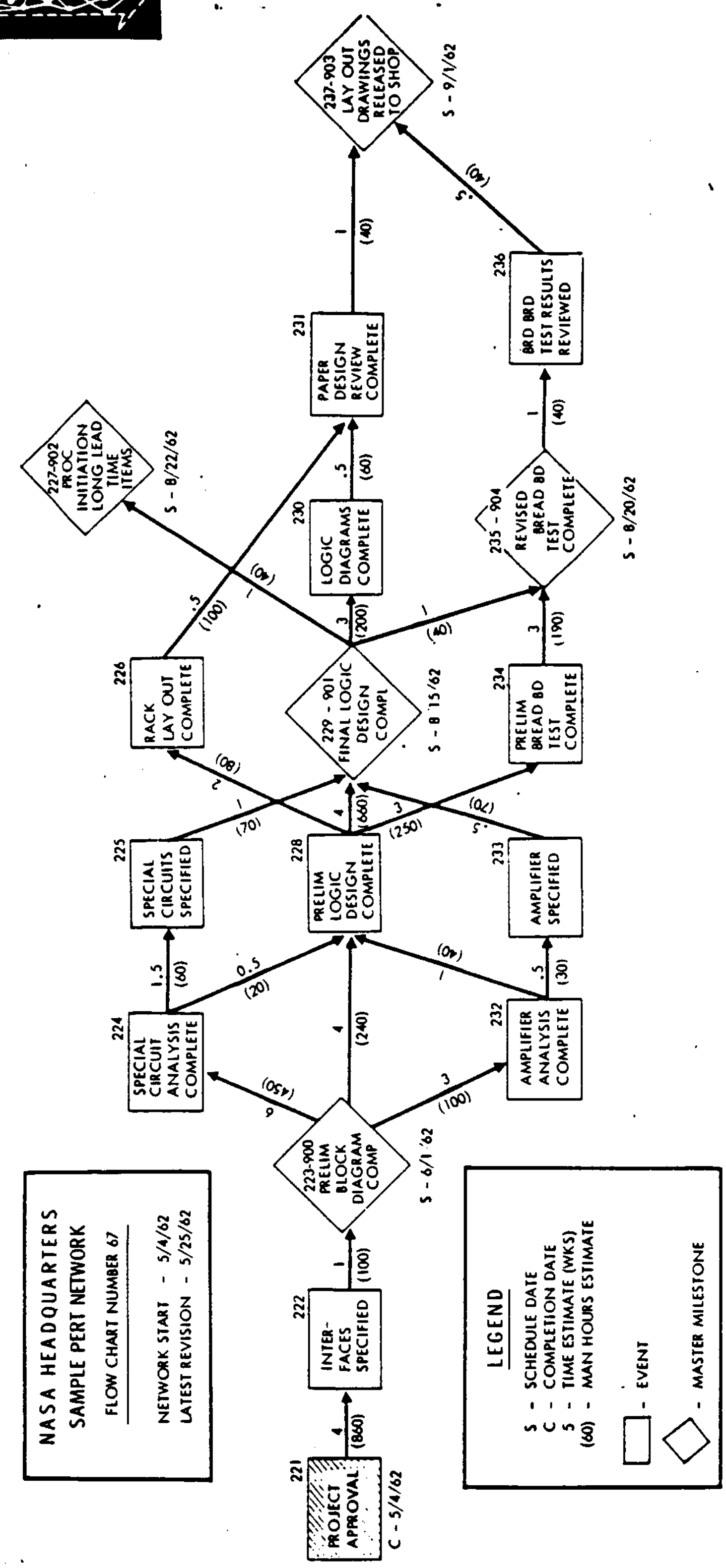

NASA HEADQUARTERS
SAMPLE PERT NETWORK
FLOW CHART NUMBER 67
NETWORK START - 5/4/62
LATEST REVISION - 5/25/62
221 PROJECT APPROVAL C - 5/4/62
4 (860)
222 INTER-FACES SPECIFIED
1 (100)
223-900 PRELIM BLOCK DIAGRAM COMP S - 6/1/62
6 (450)
4 (240)
3 (100)
224 SPECIAL CIRCUIT ANALYSIS COMPLETE
232 AMPLIFIER ANALYSIS COMPLETE
1.5 (60)
0.5 (20)
1 (40)
.5 (30)
225 SPECIAL CIRCUITS SPECIFIED
228 PRELIM LOGIC DESIGN COMPLETE
233 AMPLIFIER SPECIFIED
2 (80)
1 (70)
4 (660)
3 (250)
.5 (70)
226 RACK LAY OUT COMPLETE
229 - 901 FINAL LOGIC DESIGN COMPL S - 8/15/62
234 PRELIM BREAD BD TEST COMPLETE
.5 (100)
1 (40)
3 (200)
1 (40)
3 (190)
227-902 PROC INITIATION LONG LEAD TIME ITEMS S - 8/22/62
230 LOGIC DIAGRAMS COMPLETE
235 - 904 REVISED BREAD BD TEST COMPLETE S - 8/20/62
.5 (60)
1 (40)
231 PAPER DESIGN REVIEW COMPLETE
236 BRD BRD TEST RESULTS REVIEWED
1 (40)
.5 (40)
237-903 LAY OUT DRAWINGS RELEASED TO SHOP S - 9/1/62
LEGEND
S - SCHEDULE DATE
C - COMPLETION DATE
5 - TIME ESTIMATE (WKS)
(60) - MAN HOURS ESTIMATE
- EVENT
- MASTER MILESTONE

Fig. VII-a

NASA PERT AND COMPANION COST

NASA PERT

PAGE 1

DATE OF THIS REPORT IS 05-25-62

RUN 1 ENDING EVENT
BY SUCCESSOR EVENT NUMBER AND PREDECESSOR EVENT NUMBER
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

EVENT PRE.	EVENT SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-001	0000-221	PROJECT APPROVAL			04-14-62	A05-04-62	-2.9			HDQS
0000-221	0000-222	DEFINING INTERFACES	4.0	06-01-62	05-12-62		-2.9	860	1.0	PROJ
0000-222	0000-223	PREPARING PRELIMINARY BLOCK DIAGRAM	1.0	06-08-62	05-19-62		-2.9	100	2.0	ELEC
0000-900	0000-224	PREPARING SPECIAL CIRCUIT ANALYSIS	6.0	07-20-62	06-30-62		-2.9	150	8.0	ELEC
0000-224	0000-225	DESIGN SPECIAL CIRCUITS	1.5	07-31-62	07-25-62		-.9	60	9.5	ELEC
0000-228	0000-226	PREPARE RACK LAY OUT	2.0	08-07-62	08-22-62		2.1	80	10.5	ELEC
0000-901	0000-227	PREPARE LONG LEAD PURCHASE REQUESTS	1.0	08-28-62	08-22-62		-.8	40	13.5	PROC
0000-224	0000-228	INCORP SPEC CIRC ANAL IN PRELIM LOGIC DES	.5	07-24-62	07-04-62		-2.9	20	8.5	ELEC
0000-232	0000-228	INCORP AMPLIFIER ANAL IN PRELIM LOGIC DES	1.0	07-06-62	07-04-62		-.4	40	6.0	ELEC
0000-900	0000-228	PREPARE PRELIMINARY LOGIC DESIGN	4.0	07-06-62	07-04-62		-.4	240	6.0	ELEC
0000-225	0000-229	INCORP SPEC CIRC DES IN FINAL LOGIC DES	1.0	08-07-62	08-01-62		-.9	70	10.5	ELEC
0000-228	0000-229	PREPARE FINAL LOGIC DESIGN	4.0	08-21-62	08-01-62		-2.9	660	12.5	ELEC
0000-233	0000-229	INCORP AMPLIFIER DES IN FINAL LOGIC DES	.5	07-06-62	08-01-62		3.6	70	6.0	ELEC
0000-901	0000-230	PREPARE LOGIC DIAGRAMS	3.0	09-11-62	08-22-62		-2.9	200	15.5	ELEC
0000-226	0000-231	REVIEW RACK LAY OUT	.5	08-10-62	08-25-62		2.1	100	11.0	ELEC
0000-230	0000-231	DESIGN REVIEW OF LOGIC DIAGRAMS	.5	09-14-62	08-25-62		-2.9	60	16.0	ELEC
0000-900	0000-232	PREPARE AMPLIFIER ANALYSIS	3.0	06-29-62	06-27-62		-.4	100	5.0	ELEC
0000-232	0000-233	DESIGN AMPLIFIER	.5	07-03-62	07-28-62		3.6	30	5.5	ELEC
0000-228	0000-234	PRELIM BREADBOARD TESTING	3.0	08-14-62	08-01-62		-1.9	250	11.5	ELEC
0000-234	0000-235	REVISED BREADBOARD TESTING	3.0	09-04-62	08-22-62		-1.9	130	14.5	ELEC
0000-901	0000-235	INCORP FINAL LOGIC DESIGN IN BREADBOARD	1.0	08-28-62	08-22-62		-.9	40	13.5	ELEC
0000-904	0000-236	REVIEW BREADBOARD TEST RESULT	1.0	09-11-62	08-29-62		-1.9	40	15.5	ELEC
0000-231	0000-237	INCORP DESIGN REVISIONS IN LAY OUT DWGS	1.0	09-21-62	09-01-62		-2.9	40	17.0	ELEC
0000-236	0000-237	INCORP BREADBOARD REVISION IN LAY OUT DWGS	.5	09-14-62	09-01-62		-1.9	40	16.0	ELEC
0000-223	0000-900	PRELIMINARY BLOCK DIAGRAMS COMPLETE	.0	06-08-62	05-19-62	06-01-62	-2.9	0	2.0	ELEC
0000-229	0000-901	FINAL LOGIC DESIGN COMPLETE	.0	08-21-62	08-01-62	08-15-62	-2.9	0	12.5	ELEC
0000-227	0000-902	PROCUR INITIATION - LONG LEAD ITEMS	.0	08-28-62	08-22-62	08-22-62	-.8	0	13.5	PROC
0000-237	0000-903	LAY OUT DRAWINGS RELEASED TO SHOP	.0	09-21-62	09-01-62	09-01-62	-2.9	0	17.0	ELEC
0000-235	0000-904	REVISED BREADBOARD TEST COMPLETE	.0	09-04-62	08-22-62	08-20-62	-1.9	0	14.5	ELEC

Fig. VII-b

NASA PERT

PAGE 1

RUN 1 ENDING EVENT
BY PATHS OF CRITICALITY
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

DATE OF THIS REPORT IS 05-25-62

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-001	0000-221	PROJECT APPROVAL			04-14-62	A05-04-62	- 2.9			HDQS
0000-221	0000-222	DEFINING INTERFACES	4.0	06-01-62	05-12-62		- 2.9	860	1.0	PROJ
0000-222	0000-223	PREPARING PRELIMINARY BLOCK DIAGRAM	1.0	06-08-62	05-19-62		- 2.9	100	2.0	ELEC
0000-223	0000-900	PRELIMINARY BLOCK DIAGRAMS COMPLETE	.0	06-08-62	05-19-62	06-01-62	- 2.9	0	2.0	ELEC
0000-900	0000-224	PREPARING SPECIAL CIRCUIT ANALYSIS	6.0	07-20-62	06-30-62		- 2.9	150	8.0	ELEC
0000-224	0000-228	INCORP SPEC CIRC ANAL IN PRELIM LOGIC DES	.5	07-24-62	07-04-62		- 2.9	20	8.5	ELEC
0000-228	0000-229	PREPARE FINAL LOGIC DESIGN	4.0	08-21-62	08-01-62		- 2.9	660	12.5	ELEC
0000-229	0000-901	FINAL LOGIC DESIGN COMPLETE	.0	08-21-62	08-01-62	08-15-62	- 2.9	0	12.5	ELEC
0000-901	0000-230	PREPARE LOGIC DIAGRAMS	3.0	09-11-62	08-22-62		- 2.9	200	15.5	ELEC
0000-230	0000-231	DESIGN REVIEW OF LOGIC DIAGRAMS	.5	09-14-62	08-25-62		- 2.9	60	16.0	ELEC
0000-231	0000-237	INCORP DESIGN REVISIONS IN LAY OUT DWGS	1.0	09-21-62	09-01-62		- 2.9	40	17.0	ELEC
0000-237	0000-903	LAY OUT DRAWINGS RELEASED TO SHOP	.0	09-21-62	09-01-62	09-01-62	- 2.9	0	17.0	ELEC
0000-228	0000-234	PRELIM BREADBOARD TESTING	3.0	08-14-62	08-01-62		- 1.9	250	11.5	ELEC
0000-234	0000-235	REVISED BREADBOARD TESTING	3.0	09-04-62	08-22-62		- 1.9	190	14.5	ELEC
0000-235	0000-904	REVISED BREADBOARD TEST COMPLETE	.0	09-04-62	08-22-62	08-20-62	- 1.9	0	14.5	ELEC
0000-904	0000-236	REVIEW BREADBOARD TEST RESULT	1.0	09-11-62	08-29-62		- 1.9	40	15.5	ELEC
0000-236	0000-237	INCORP BREADBOARD REVISION IN LAY OUT DWGS	.5	09-14-62	09-01-62		- 1.9	40	16.0	ELEC
0000-224	0000-225	DESIGN SPECIAL CIRCUITS	1.5	07-31-62	07-25-62		- .9	60	9.5	ELEC
0000-225	0000-229	INCORP SPEC CIRC DES IN FINAL LOGIC DES	1.0	08-07-62	08-01-62		- .9	70	10.5	ELEC
0000-901	0000-235	INCORP FINAL LOGIC DESIGN IN BREADBOARD	1.0	08-28-62	08-22-62		- .9	40	13.5	ELEC
0000-901	0000-227	PREPARE LONG LEAD PURCHASE REQUESTS	1.0	08-28-62	08-22-62		- .8	40	13.5	PROC
0000-227	0000-902	PROCUR INITIATION - LONG LEAD ITEMS	.0	08-28-62	08-22-62	08-22-62	- .8	0	13.5	PROC
0000-900	0000-232	PREPARE AMPLIFIER ANALYSIS	3.0	06-29-62	06-27-62		- .4	100	5.0	ELEC
0000-232	0000-228	INCORP AMPLIFIER ANAL IN PRELIM LOGIC DES	1.0	07-06-62	07-04-62		- .4	40	6.0	ELEC
0000-900	0000-228	PREPARE PRELIMINARY LOGIC DESIGN	4.0	07-06-62	07-04-62		- .4	240	6.0	ELEC
0000-228	0000-226	PREPARE RACK LAY OUT	2.0	08-07-62	08-22-62		2.1	80	10.5	ELEC
0000-226	0000-231	REVIEW RACK LAY OUT	.5	08-10-62	08-25-62		2.1	100	11.0	ELEC
0000-232	0000-233	DESIGN AMPLIFIER	.5	07-03-62	07-28-62		3.6	30	5.5	ELEC

Fig. VII-c

NASA PERT AND COMPANION COST

NASA PERT PAGE 2

DATE OF THIS REPORT IS 05-25-62

RUN 1 ENDING EVENT
BY PATHS OF CRITICALITY
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

EVENT PRE.	EVENT SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-233	0000-229	INCORP AMPLIFIER DES IN FINAL LOGIC DES	.5	07-06-62	08-01-62		3.6	70	6.0	ELEC

Fig. VII-d

NASA PERT

PAGE 1

RUN 1 ENDING EVENT DATE 05-25-62
BY EXPECTED DATE AND SUCCESSOR EVENT NUMBER
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE- SOURCE	TIME REM.	ORG
0000-001	0000-221	PROJECT APPROVAL			04-14-62	A05-04-62	- 2.9			HDQS
0000-221	0000-222	DEFINING INTERFACES	4.0	06-01-62	05-12-62		- 2.9	860	1.0	PROJ
0000-222	0000-223	PREPARING PRELIMINARY BLOCK DIAGRAM	1.0	06-08-62	05-19-62		- 2.9	100	2.0	ELEC
0000-223	0000-900	PRELIMINARY BLOCK DIAGRAMS COMPLETE	.0	06-08-62	05-19-62	06-01-62	- 2.9	0	2.0	ELEC
0000-900	0000-232	PREPARE AMPLIFIER ANALYSIS	3.0	06-29-62	06-27-62		- .4	100	5.0	ELEC
0000-232	0000-233	DESIGN AMPLIFIER	.5	07-03-62	07-28-62		3.6	30	5.5	ELEC
0000-232	0000-228	INCORP AMPLIFIER ANAL IN PRELIM LOGIC DES	1.0	07-06-62	07-04-62		- .4	40	6.0	ELEC
0000-900	0000-228	PREPARE PRELIMINARY LOGIC DESIGN	4.0	07-06-62	07-04-62		- .4	240	6.0	ELEC
0000-233	0000-229	INCORP AMPLIFIER DES IN FINAL LOGIC DES	.5	07-06-62	08-01-62		3.6	70	6.0	ELEC
0000-900	0000-224	PREPARING SPECIAL CIRCUIT ANALYSIS	6.0	07-20-62	06-30-62		- 2.9	150	8.0	ELEC
0000-224	0000-228	INCORP SPEC CIRC ANAL IN PRELIM LOGIC DES	.5	07-24-62	07-04-62		- 2.9	20	8.5	ELEC
0000-224	0000-225	DESIGN SPECIAL CIRCUITS	1.5	07-31-62	07-25-62		- .9	60	9.5	ELEC
0000-225	0000-229	INCORP SPEC CIRC DES IN FINAL LOGIC DES	1.0	08-07-62	08-01-62		- .9	70	10.5	ELEC
0000-228	0000-226	PREPARE RACK LAY OUT	2.0	08-07-62	08-22-62		2.1	80	10.5	ELEC
0000-226	0000-231	REVIEW RACK LAY OUT	.5	08-10-62	08-25-62		2.1	100	11.0	ELEC
0000-228	0000-234	PRELIM BREADBOARD TESTING	3.0	08-14-62	08-01-62		- 1.9	250	11.5	ELEC
0000-228	0000-229	PREPARE FINAL LOGIC DESIGN	4.0	08-21-62	08-01-62		- 2.9	660	12.5	ELEC
0000-229	0000-901	FINAL LOGIC DESIGN COMPLETE	.0	08-21-62	08-01-62	08-15-62	- 2.9	0	12.5	ELEC
0000-901	0000-235	INCORP FINAL LOGIC DESIGN IN BREADBOARD	1.0	08-28-62	08-22-62		- .9	40	13.5	ELEC
0000-901	0000-227	PREPARE LONG LEAD PURCHASE REQUESTS	1.0	08-28-62	08-22-62		- .8	40	13.5	PROC
0000-227	0000-902	PROCUR INITIATION - LONG LEAD ITEMS	.0	08-28-62	08-22-62	08-22-62	- .8	0	13.5	PROC
0000-234	0000-235	REVISED BREADBOARD TESTING	3.0	09-04-62	08-22-62		- 1.9	190	14.5	ELEC
0000-235	0000-904	REVISED BREADBOARD TEST COMPLETE	.0	09-04-62	08-22-62	08-20-62	- 1.9	0	14.5	ELEC
0000-901	0000-230	PREPARE LOGIC DIAGRAMS	3.0	09-11-62	08-22-62		- 2.9	200	15.5	ELEC
0000-904	0000-236	REVIEW BREADBOARD TEST RESULT	1.0	09-11-62	08-29-62		- 1.9	40	15.5	ELEC
0000-230	0000-231	DESIGN REVIEW OF LOGIC DIAGRAMS	.5	09-14-62	08-25-62		- 2.9	60	16.0	ELEC
0000-236	0000-237	INCORP BREADBOARD REVISION IN LAY OUT DWGS	.5	09-14-62	09-01-62		- 1.9	40	16.0	ELEC
0000-231	0000-237	INCORP DESIGN REVISIONS IN LAY OUT DWGS	1.0	09-21-62	09-01-62		- 2.9	40	17.0	ELEC
0000-237	0000-903	LAY OUT DRAWINGS RELEASED TO SHOP	.0	09-21-62	09-01-62	09-01-62	- 2.9	0	17.0	ELEC

Fig. VII-e

NASA PERT

PAGE 1

RUN 1 ENDING EVENT
BY DEPARTMENT, SCHEDULE OR EXPECTED DATE, AND SUCCESSOR EVENT
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

DATE OF THIS REPORT IS 05-25-62

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-222	0000-223	PREPARING PRELIMINARY BLOCK DIAGRAM	1.0	06-08-62	05-19-62		- 2.9	100	2.0	ELEC
0000-223	0000-900	PRELIMINARY BLOCK DIAGRAMS COMPLETE	.0	06-08-62	05-19-62	06-01-62	- 2.9	0	2.0	ELEC
0000-900	0000-232	PREPARE AMPLIFIER ANALYSIS	3.0	06-29-62	06-27-62		- .4	100	5.0	ELEC
0000-232	0000-233	DESIGN AMPLIFIER	.5	07-03-62	07-28-62		3.6	30	5.5	ELEC
0000-232	0000-228	INCORP AMPLIFIER ANAL IN PRELIM LOGIC DES	1.0	07-06-62	07-04-62		- .4	40	6.0	ELEC
0000-900	0000-228	PREPARE PRELIMINARY LOGIC DESIGN	4.0	07-06-62	07-04-62		- .4	240	6.0	ELEC
0000-233	0000-229	INCORP AMPLIFIER DES IN FINAL LOGIC DES	.5	07-06-62	08-01-62		3.6	70	6.0	ELEC
0000-900	0000-224	PREPARING SPECIAL CIRCUIT ANALYSIS	6.0	07-20-62	06-30-62		- 2.9	150	8.0	ELEC
0000-224	0000-228	INCORP SPEC CIRC ANAL IN PRELIM LOGIC DES	.5	07-24-62	07-04-62		- 2.9	20	8.5	ELEC
0000-224	0000-225	DESIGN SPECIAL CIRCUITS	1.5	07-31-62	07-25-62		- .9	60	9.5	ELEC
0000-228	0000-226	PREPARE RACK LAY OUT	2.0	08-07-62	08-22-62		2.1	80	10.5	ELEC
0000-225	0000-229	INCORP SPEC CIRC DES IN FINAL LOGIC DES	1.0	08-07-62	08-01-62		- .9	70	10.5	ELEC
0000-226	0000-231	REVIEW RACK LAY OUT	.5	08-10-62	08-25-62		2.1	100	11.0	ELEC
0000-228	0000-234	PRELIM BREADBOARD TESTING	3.0	08-14-62	08-01-62		- 1.9	250	11.5	ELEC
0000-228	0000-229	PREPARE FINAL LOGIC DESIGN	4.0	08-21-62	08-01-62		- 2.9	660	12.5	ELEC
0000-229	0000-901	FINAL LOGIC DESIGN COMPLETE	.0	08-21-62	08-01-62	08-15-62	- 2.9	0	12.5	ELEC
0000-901	0000-235	INCORP FINAL LOGIC DESIGN IN BREADBOARD	1.0	08-28-62	08-22-62		- .9	40	13.5	ELEC
0000-234	0000-235	REVISED BREADBOARD TESTING	3.0	09-04-62	08-22-62		- 1.9	190	14.5	ELEC
0000-235	0000-904	REVISED BREADBOARD TEST COMPLETE	.0	09-04-62	08-22-62	08-20-62	- 1.9	0	14.5	ELEC
0000-901	0000-230	PREPARE LOGIC DIAGRAMS	3.0	09-11-62	08-22-62		- 2.9	200	15.5	ELEC
0000-904	0000-236	REVIEW BREADBOARD TEST RESULT	1.0	09-11-62	08-29-62		- 1.9	40	15.5	ELEC
0000-230	0000-231	DESIGN REVIEW OF LOGIC DIAGRAMS	.5	09-14-62	08-25-62		- 2.9	60	16.0	ELEC
0000-236	0000-237	INCORP BREADBOARD REVISION IN LAY OUT DWGS	.5	09-14-62	09-01-62		- 1.9	40	16.0	ELEC
0000-231	0000-237	INCORP DESIGN REVISIONS IN LAY OUT DWGS	1.0	09-21-62	09-01-62		- 2.9	40	17.0	ELEC
0000-237	0000-903	LAY OUT DRAWINGS RELEASED TO SHOP	.0	09-21-62	09-01-62	09-01-62	- 2.9	0	17.0	ELEC

NASA PERT AND COMPANION COST

Fig. VII-f

NASA PERT

PAGE 2

RUN 1 ENDING EVENT DATE OF THIS REPORT IS 05-25-62
BY DEPARTMENT, SCHEDULE OR EXPECTED DATE, AND SUCCESSOR EVENT
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-001	0000-221	PROJECT APPROVAL			04-14-62	*05-04-62	- 2.9			HDOS

Fig. VII-g

NASA PERT

PAGE 3

DATE OF THIS REPORT IS 05-25-62

RUN 1 ENDING EVENT
BY DEPARTMENT, SCHEDULE OR EXPECTED DATE, AND SUCCESSOR EVENT
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

EVENT PRE.	EVENT SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-901	0000-227	PREPARE LONG LEAD PURCHASE REQUESTS	1.0	08-28-62	08-22-62		- .8	40	13.5	PROC
0000-227	0000-902	PROCUR INITIATION - LONG LEAD ITEMS	.0	08-28-62	08-22-62	08-22-62	- .8	0	13.5	.PROC

Fig. VII-h

NASA PERT AND COMPANION COST

NASA PERT
*

PAGE 4

RUN 1 ENDING EVENT

BY DEPARTMENT, SCHEDULE OR EXPECTED DATE, AND SUCCESSOR EVENT

NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

DATE OF THIS REPORT IS 05-25-62

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	RE-SOURCE	TIME REM.	ORG
0000-221	0000-222	DEFINING INTERFACES	8.0	06-01-62	05-12-62		- 2.9	860	1.0	PROJ

Fig. VII-i

NASA PERT

PAGE 1

DATE OF THIS REPORT IS 05-25-62

RUN 1 ENDING EVENT
MASTER SCHEDULE
NETWORK NP PERT SAMPLE NETWORK FIRST RUN 05-09-62

EVENT	ACTIVITY DESCRIPTION	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	TIME REM.	ORG
0000-900	PRELIMINARY BLOCK DIAGRAMS COMPLETE	06-08-62	05-19-62	06-01-62	- 2.9	2.0	ELEC
0000-901	FINAL LOGIC DESIGN COMPLETE	08-21-62	08-01-62	08-15-62	- 2.9	12.5	ELEC
0000-902	PROCUR INITIATION - LONG LEAD ITEMS	08-28-62	08-22-62	08-22-62	- .8	13.5	PROC
0000-904	REVISED BREADBOARD TEST COMPLETE	09-04-62	08-22-62	08-20-62	- 1.9	14.5	ELEC
0000-903	LAY OUT DRAWINGS RELEASED TO SHOP	09-21-62	09-01-62	09-01-62	- 2.9	17.0	ELEC

Fig. VII-j

SECTION VIII

MASTER PLANS

GENERAL

The master schedule and the master cost and financial plan are key elements of the NASA-PERT and Companion Cost System. They represent the official project plans and are used to:

- Assess progress against plans.
- Communicate project status.

MASTER SCHEDULE

Master schedules are developed and approved in accordance with the procedures outlined in Section V. In general, development of the master schedule begins during the NASA in-house conceptual planning of the project. These schedules are adjusted and refined as the project becomes more definitized resulting in an approved project master schedule.

The master schedule is a selected list of key events on the NASA-PERT network. The PERT expected and latest allowable dates are used to assist in the establishment of scheduled dates for these events but are not automatically accepted as the scheduled date. Other factors such as the following must be considered:

- The availability of required manpower, equipment and facilities during specific calendar periods.
- Minimization of premium costs and idle time for manpower, equipment, and facilities.
- Funding limitations.
- The manager's judgment as to what is a reasonable time to allow for performing the work.

Only after reviewing these factors should a manager establish firm schedule completion dates for the milestones appearing on the master schedule. As the project progresses, unforeseen technical difficulties or changes in resources, policy or technical specifications can result in a fluctuating outlook for the completion of master schedule events. This does not mean that the schedule dates for these milestones should be changed every time a new computer report is processed. The computer output serves as a basis for rather than a substitute for action and judgment by the project manager. The report and the significance of it must be analyzed, alternate courses of action considered, and the effect of adjustments in resources determined (etc.) before the actual plan (master schedule) is revised. So long as a reasonable possibility of accomplishing the original plan exists it should not be modified.

By proper keying of master schedule events the computer tabulation can be oriented towards various project objectives. (For example, all key events leading up to a certain flight or all events related to a certain system for all flights.) These various orientations can be printed on separate pages for rapid dissemination of the information.

As generated by the computer, the master schedule is tabular in format (see Fig. VII-f). To assist in communication of this data it is often converted to graphical presentation (see Fig. VIII-a). Although significant progress has been made in the area of computer-generated graphical presentations, the present state of the development does not permit the replacement of the more time consuming yet flexible manual method. To ensure uniformity in presentation and meaning the following standards and procedures apply:

The graphic portrayal of the master schedules will include the following as illustrated in Fig. VIII-a.

- Title

  Sufficiently identifying of project and subsidiary work breaks to prevent confusion.

- Time Scale

  Normally in months with fiscal and calendar years shown.

- Work Breaks

  Major elements and sub-elements of the project of sufficient importance to be scheduled by the project manager.

- Glossary of Milestones

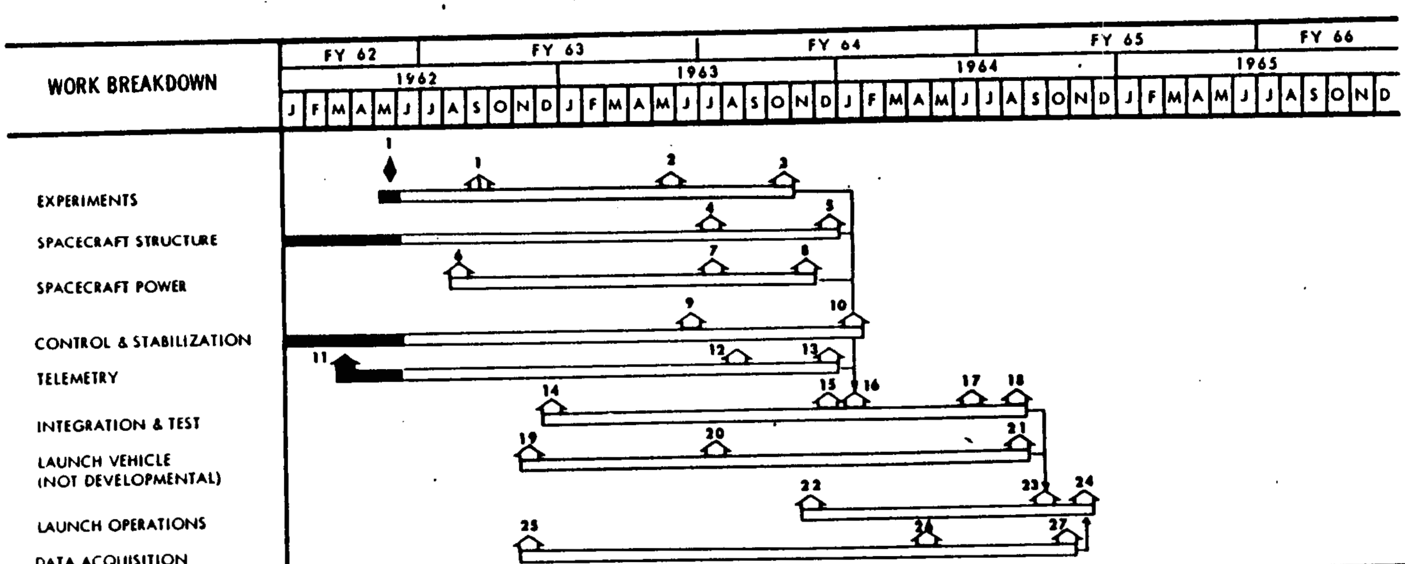
  Identification of the events scheduled.

- Remarks

  This space will be used for any reference or comments necessary to clarify schedule data.

The master schedule will use the symbols shown in Fig. VIII-b. Fig. VIII-c shows examples of potential scheduling situations.

PROJECT DAEDALUS
MASTER SCHEDULE



GLOSSARY OF MILESTONES

1 - ALL CONTRACTS AWARDED
2 - START TESTING PROGRAM
3 - FLIGHT EXPERIMENTS QUALIFIED
4 - MANUFACTURE COMPLETE
5 - TESTING COMPLETE
6 - CONTRACT AWARD
7 - FABRICATION COMPLETE
8 - TESTING COMPLETE
9 - START TESTING PROTOTYPE
10 - COMPLETE ENVIRONMENTAL TEST
11 - CONTRACT AWARD
12 - START ACCEPTANCE TESTING
13 - TELEMETRY QUALIFIED
14 - START FACILITY PLANNING
15 - TEST FACILITIES AVAILABLE
16 - START SPACECRAFT TESTING
17 - START ENVIRONMENTAL TEST
18 - COMPLETE ENVIRONMENTAL TEST
19 - PLACE VEHICLE ORDER
20 - VEHICLE MODIFICATIONS COMPLETE
21 - VEHICLE DELIVERED TO RANGE
22 - START RANGE DOCUMENTATION
23 - BEGIN MATING OPERATION
24 - LAUNCH
25 - FACILITY AND EQUIPMENT DETERMINED
26 - BENEFICIAL OCCUPANCY
27 - FACILITY OPERATIONAL

REMARKS

1. THIS SCHEDULE ASSUMES FUNDING IN FY'S 63, 64, & 65 IN ACCORDANCE WITH THE MASTER FUNDING PLAN.

NASA PERT AND COMPANION COST

Fig. VIII - a

STANDARD SYMBOLS
FOR
MASTER SCHEDULES

MILESTONE SYMBOLS

BASIC SYMBOLS	MEANING
	SCHEDULED EVENT - ONE TIME
	EVENT COMPLETED
	ANTICIPATED SLIPPAGE } Always Used In Conjunction With A Scheduling Arrow.
	ACTUAL SLIPPAGE } Always Used In Conjunction With A Scheduling Arrow.
	RESCHEDULED EVENT - Number Indicates Rescheduling Sequences Also Used With Diamond
	THIS SYMBOL INDICATES COMPLETION AHEAD OF SCHEDULE
	INTERFACE CONSTRAINT

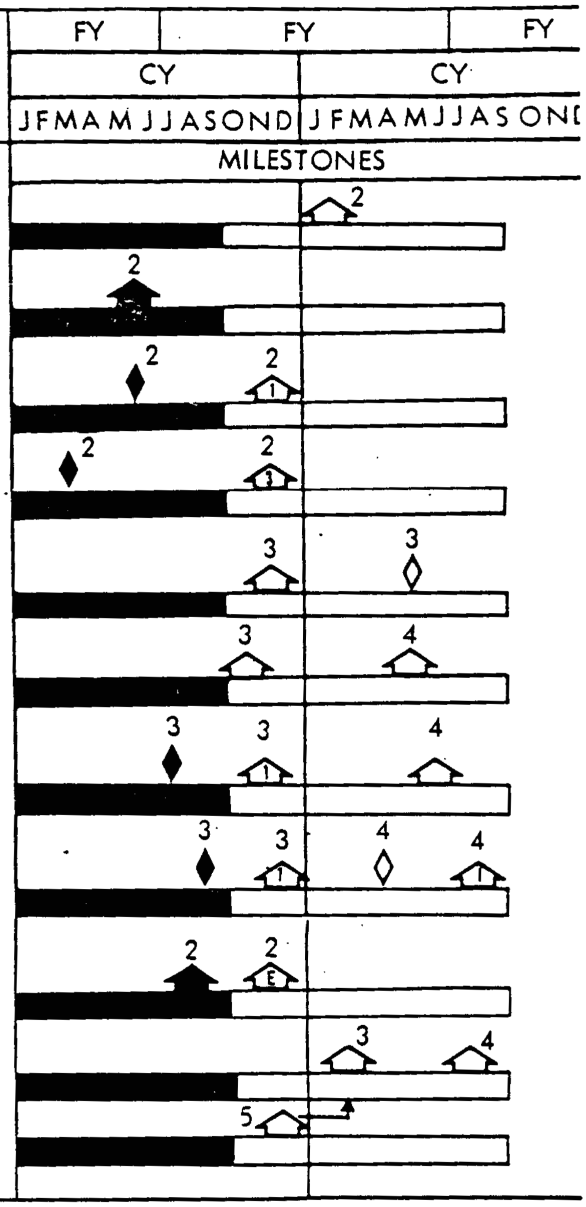
Fig. VIII - b

SAMPLE SCHEDULING SITUATIONS

TIME SPAN

ELEMENTS SCHEDULED

1. Scheduled, One Event
2. Completed, One Event
3. Target Date Slipped, Rescheduled
4. Target Date Slipped Three Times, Rescheduled
5. Potential slippage, rescheduling under consideration. (ie PERT expected date)
6. Time Span Action
7. Time Span Action Slip (Start)
8. Time Span Action Slip (Start & Finish)
9. Completed Ahead of Schedule
10. Interface Constraint (5 to 3). Events Which Affect Other Events Should Be Connected Directly Without Reguard to Slack Or Leadtime.



GLOSSARY OF MILESTONES

2. Preliminary First Stage Contract
3. Start Static Test Program
4. Complete Static Test Program
5. Complete Static Test Facility

Fig. VIII - c

MASTER FINANCIAL PLAN

General Description

The companion Master Financial Plan, like the master schedule portrays the project from "cradle to grave." Also, like its companion master schedule it communicates planning information as well as a record of actuals on a total project basis. It, therefore, serves as a:

- planning and replanning instrument,
- a record of current and planned dollar requirements and authorizations,
- a device for assessment of actual dollar encumbrances incurred in terms of commitments, obligations, and costs,
- a necessary companion to the master schedule when making a correlated analysis of total project status in terms of time and cost.

The Master Financial Plan actually consists of two closely related parts—a Master Cost Plan and a Master Funding Plan. The two parts of the master financial plan are, in fact, so closely interrelated, they are graphically portrayed on the same chart. However, for clarity in the discussion below, the cost plan and the funding plan are treated separately. Both reflect the total dollar resources required for the project, time-phased through completion of all work. Obviously, at the end of the project, total costs should equal total funding. However, at any time period before completion cumulative funding will be greater than cumulative accrued costs. This will always be the case since the incurrence of costs (as the measure of resources utilized regardless of when paid for or received) must be preceded by the authorized availability of funds.

The purpose of the funding plan is to indicate the time-phased requirements as to when funds should be authorized for and available to the project. Other purposes are to determine annual budget requests, allotment requirements and project commitment and obligation plans. The cost plan serves somewhat different purposes. It serves as the primary financial tool for integrated time/cost project management by providing the basis for comparing resources consumed with physical accomplishment as reflected on the PERT network. Since under most circumstances a change in either the cost or funding plan will result in a change in the other, they in fact form a single Master Financial Plan.

Cost Plan

The essentials of the Cost Plan are:

- the officially approved estimate of the planned total cost, time-phased to completion of the project,

- reporting of accrued costs incurred to date and time-phased re-estimates of anticipated accrued cost to completion.

The desired basis of the Master Cost Plan is to use actual and anticipated accrued costs in totaling all elements of the project. This is possible only with compatibility between contractor and in-house financial information. Contractor reporting on Form 533 requires, among other things, accrued cost data but, in-house accounting is still on a commitment, obligation and expenditure basis. Because of this incompatibility, guidelines for presenting cost plans under existing circumstances are set forth at the end of this section.

Funding Plan

The essentials of the Funding Plan are:

- officially approved estimate of the planned total funding required, time-phased to completion of the project,

- reporting of actual commitments to date and time-phased re-estimate of commitments to completion of the project.

Fund availability for this purpose means receipt by the project manager of proper authority to commit and obligate funds. This availability then permits the manager to proceed with in-house work and make commitments for the subsequent obligation of funds or contract. Contractors usually desire the government to finance (i.e., incur a legal obligation) estimated accrued costs plus estimated unfilled orders on the contractor's books through some future date. Commitments normally must precede an obligation and also require the availability of funds within NASA. Thus funding in the form of commitment authority to the project manager is necessary before a contractor's projected accrued costs and unfilled orders can be funded through the contract instrument.

Development

The Master Financial Plan must include all project components; i.e., all relevant contracts and in-house work—the same scope of work as the master schedule. A preliminary project-wide funding plan is prepared as soon as the project is sufficiently well planned in-house in NASA to permit estimating its total cost. As soon as there is sufficient definition of the project a preliminary cost plan is prepared. Both the cost plan and funding plan get progressively more refined and objective as project plans (both schedule and technical) are definitized. Each must be made compatible with the other.

Before establishing the Official Master Financial Plan, consisting of cost and funding elements, many factors must be considered by the manager and his staff support groups. These factors include:

- unanticipated costs normally associated with research and development programs,

- the leadtime necessary in requesting and obtaining approval of the required fund availability,

- the work plan and its phasing as shown in the master schedule,

- the same considerations applicable in establishing the master schedule as discussed on page VIII-1.

The first official funding plan is established with the approval of the Project Approval Document. The official cost plan necessary to complete the Master Financial Plan should be established as soon afterwards as possible. If the procedures of this handbook have been followed prior to and during contract source evaluation and negotiation, a definitive time-cost base will have been established. As time passes and changes occur in the project and in the outlook for fund availability, projections of expected accrued costs and of fund availability reported against the plans will fluctuate back and forth around the fund and cost plans. This does not mean that the manager should change the plan every time a projection shows a variance with the plan. This would be impractical as the projection is only one indicator for a manager in appraising status and it must be considered in the light of other factors. Rather, at such time as the projection begins to show a consistent pattern of increasing variation from plan, in spite of management action, then the plan should be studied for possible modification for closer identification with the projection.

Graphic Portrayal

To ensure comparability between various NASA projects and to increase management understanding through uniform presentation, the graphic portrayal of the Master Financial Plan for all projects is as illustrated in Fig. VIII-d with the elements defined below:

- Title—as contained in the Project Approval Document.

- Time Scale—in months with both fiscal and calendar years shown.

- Dollar Scale—appropriate to the project being presented.

- Report Date—vertical line drawn through the "as of" date of the information.

- Funding Plan—reflect in fiscal year increments the official estimate of fund availability in terms of commitment authority required to be released to the project.

- Cost Plan—the officially approved planned cost of the project showing cumulative accrued costs through the end of each appropriate time period through completion.

- Commitments (actuals)—commitments through the report date from the official NASA accounting records.

- Costs (actuals)—costs actually accrued through the report date and obtained from appropriate contractor-submitted Forms 533 and from in-house records (on an accrued cost basis when available).

- Expected Costs—smooth curve representation of currently expected cumulative accrued costs through completion.

- Current Commitments Required—smooth curve representation of commitments required to cover currently expected cumulative accrued costs.

- Variances—for funding to-date variances indicate the difference between the funding plan and actual commitments. For accrued costs to-date indicate the difference between the cost plan and actual costs. For the variance at completion (which is identical in terms of either funding or accrued costs) indicate the difference between the planned total cost and the expected total funding or total accrued costs.

Detailed Financial Plans

The master financial plan for the total project, Fig. VIII-d, portrays the project totals only. It may, of course, be backed up by subsidiary financial plans for single contracts or for in-house work at a single NASA installation.

The highest level of time/cost correlation for any project is, of course, the total cost for the total project. Meaningful planning and status analysis requires, however, breakdown of the total project figures to that segment of work and down to that level of detail in the project work breakdown structure appropriate to the responsibility of sub-managers for getting the work done on their assigned segments within the project. In this regard, attention is again directed to the discussions in Chapter III, page 1, and Chapter IV on guidelines to use in establishing the work breakdown structure so that responsibilities of the individual sub-manager within the project are defined in terms of time (fragnets) and matching cost categories. The complexity of the project organization, the division of internal project management responsibilities, the contracting structure, and, the multiplicity of accounting systems are constraining factors to be considered in the structuring of the PERT fragnets and companion cost categories. Succinctly, cost correlation must be built-in in order to achieve an operating time/cost management tool. As described throughout this handbook the top-down approach must be used so that costs may be summarized from the most detailed level of the work breakdown structure up to the first order break nearest the top of the structure.

Presentation Based on Existing In-House Accounting Systems

The previous discussion is based on a project-wide master financial plan assuming the availability of accrued cost accounting data on in-house work. Until such cost information is available some compromises will have to be made in presenting the accrued cost

NASA PERT AND COMPANION COST

PROJECT DAEDALUS

MASTER FINANCIAL PLAN

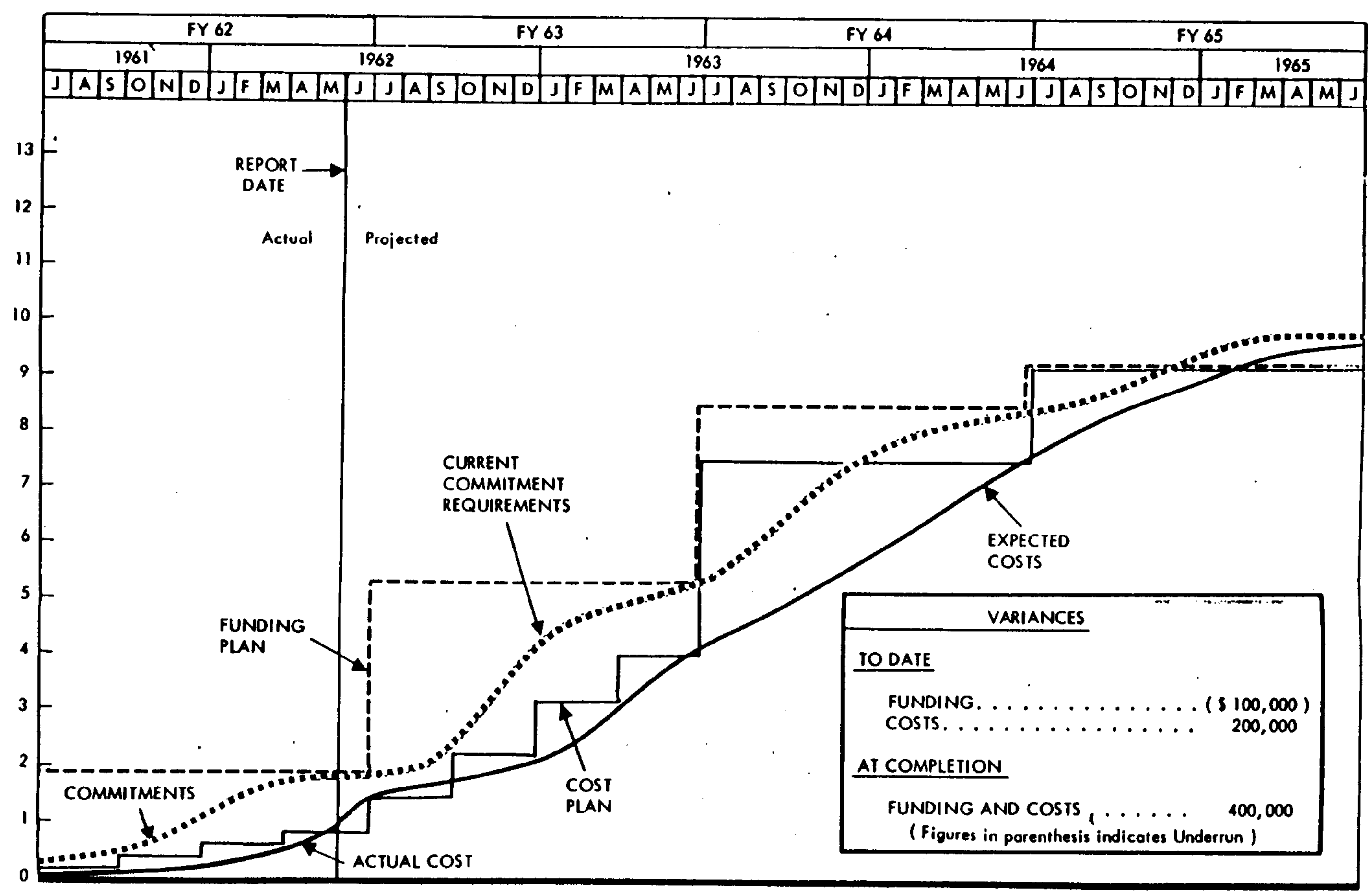


Fig. VIII - d

portion of the plan. The funding plan portion is not affected. For contracts where Form 533 or equivalent is not required and for in-house work two alternative approaches are possible. Either approach makes use of internal project obligation plans. Where the small contracts and in-house work are a small proportion of the total project, obligation data can be added directly to accrued cost information without significantly affecting the total picture on a project-wide basis. Alternatively, when obligation data is an important portion of the total, an approximation of accrued costs should be estimated with the best known information of when the resources will be consumed. The cost plan should be presented covering only contractors' reported accrued costs unless the obligation data is a very small proportion of the total project or unless converting obligation plans to an estimated accrued cost basis is considered to be sufficiently accurate to be meaningful. When only major contractors' costs are included, the presentation should be supplemented to show small contract and in-house data on an obligation basis. Whatever method of presentation is used it should be clearly indicated on the master financial plan.

SECTION IX

ANALYSIS AND MANAGEMENT ACTION

GENERAL

The preceding sections of this handbook have defined the NASA-PERT and Companion Cost System and described its operation and the manner in which data is generated. This section discusses the use of this data, and its interpretation and presentation to management.

The utilization of the data generated by the NASA-PERT and Companion Cost System follows the steps in a normal management cycle. That is, the operational input data is compared to an approved plan, corrective action initiated as necessary and plans modified accordingly. The steps in the cycle illustrated in Fig. IX-a are described in detail in succeeding paragraphs.

ANALYSIS AND MANAGEMENT ACTION CYCLE

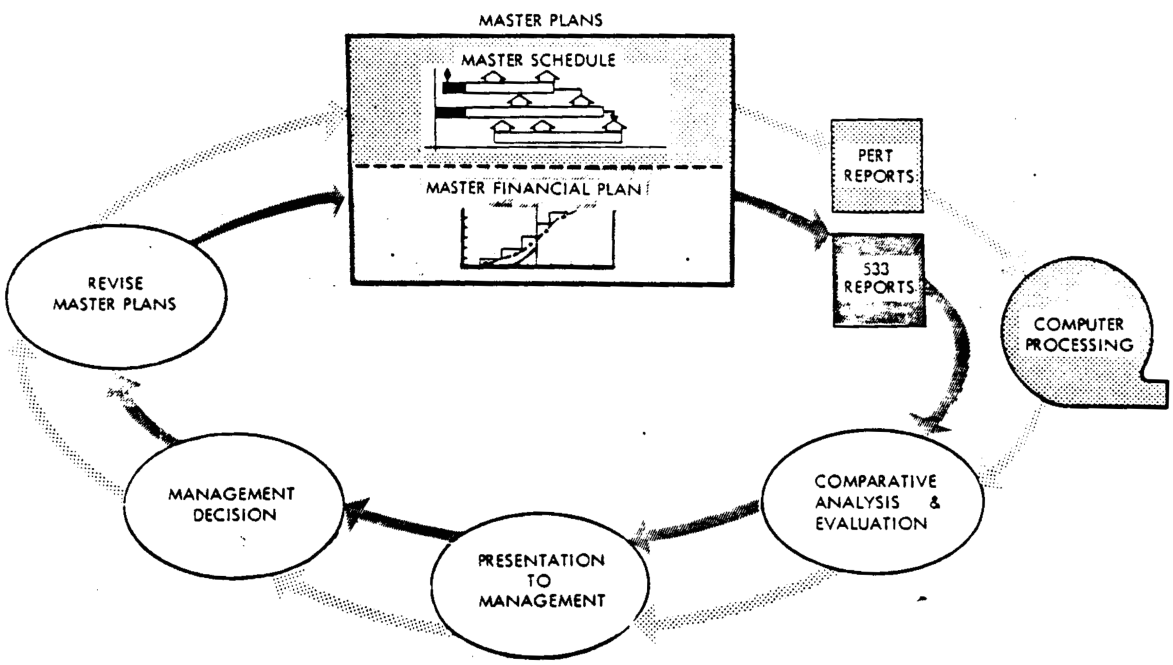


Fig. IX-a

LIMITATIONS

The present NASA-PERT and Companion Cost System has several limitations that should be pointed out before going into a more detailed discussion of the data analysis. Namely:

The time and cost data are not necessarily on the same time reporting cycle nor do they necessarily refer to the same precise period of time. The PERT data is on a two-week cycle whereas the cost data is on a monthly cycle. In cases where the contractor is on a thirteen-month (four-week) accounting cycle, adjustments can be made so that every other PERT report is phased with a cost report. In all other cases there will be some time phasing in the currency of the time and cost data. At first glance this may appear to be a serious handicap. However, considering the gross level of detail in both the NASA-PERT and cost structures, a weeks difference in phasing is not considered too serious.

The PERT data is mechanized on a computer whereas the cost data must be processed manually until such time as computer processing procedures can be integrated into the NASA-PERT computer program. As a result, the computer will not necessarily sort out all potential problem areas on an exception basis. A careful and complete analysis of cost data reported for every subdivision of work account in relation to the progress represented on the corresponding PERT fragnet is required. If this is not done, potential overrun situations may be developing and not be detected until several months later.

The fact that the cost data is not mechanized also limits achieving the desired level of time/cost correlation as discussed in Section IV. This again emphasizes the need for a careful and complete analysis of time and cost data at the subdivision of work level.

COMPARATIVE ANALYSIS AND EVALUATION

A comparative analysis and evaluation of the NASA-PERT time data and the 533 cost data is the first step in the overall analysis and management action cycle depicted in Fig. IX-a. Precise procedures for analysis and evaluation are difficult to define since they vary from case to case depending on what the analyst finds. However, it is possible to illustrate the type of reasoning and questioning that must be exercised to accomplish a thorough analysis and evaluation.

Outlook Comparison

Generally, the first step in any analysis is to compare the overall outlook with the previous outlook. A quick look reading will tell whether the expected date for meeting the end objective and key intermediate master schedule milestones (events) is earlier than, the same as, or later than the previous outlook. A comparison of the overall outlook in comparison to scheduled dates is reflected in an outlook trend chart as illustrated in Fig. IX-b. This is a time vs. time plot which shows successive PERT outlooks for meeting the end objective. Similar plots should be maintained for all major milestones.

SCHEDULE OUTLOOK TREND

PROJECT: DAEDALUS	REPORT DATE: 5/25/61
SYS/SUB SYS : TOTAL PROJECT	EVENT SCHEDULED - FIRST LAUNCH

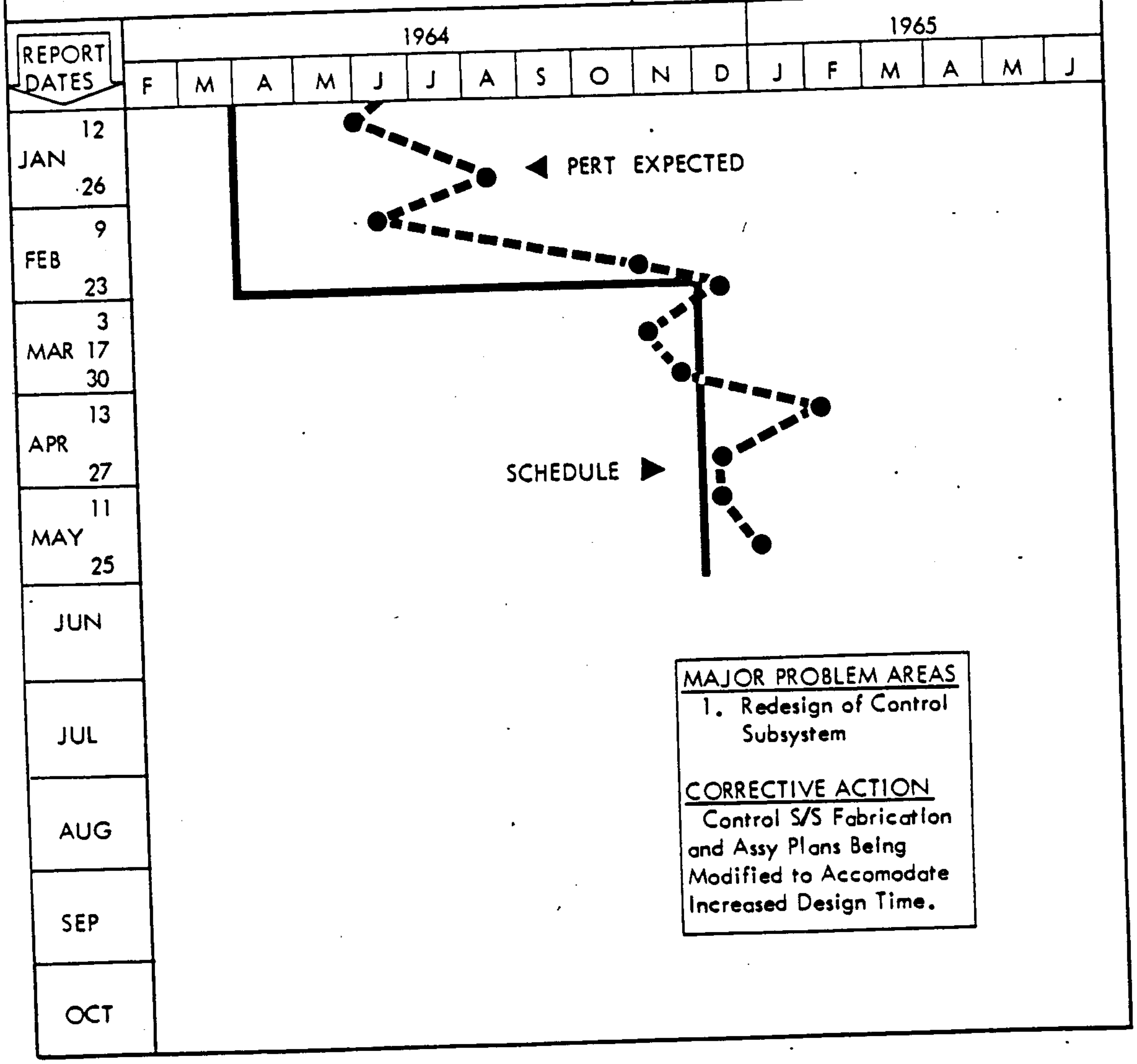


Fig. IX-b

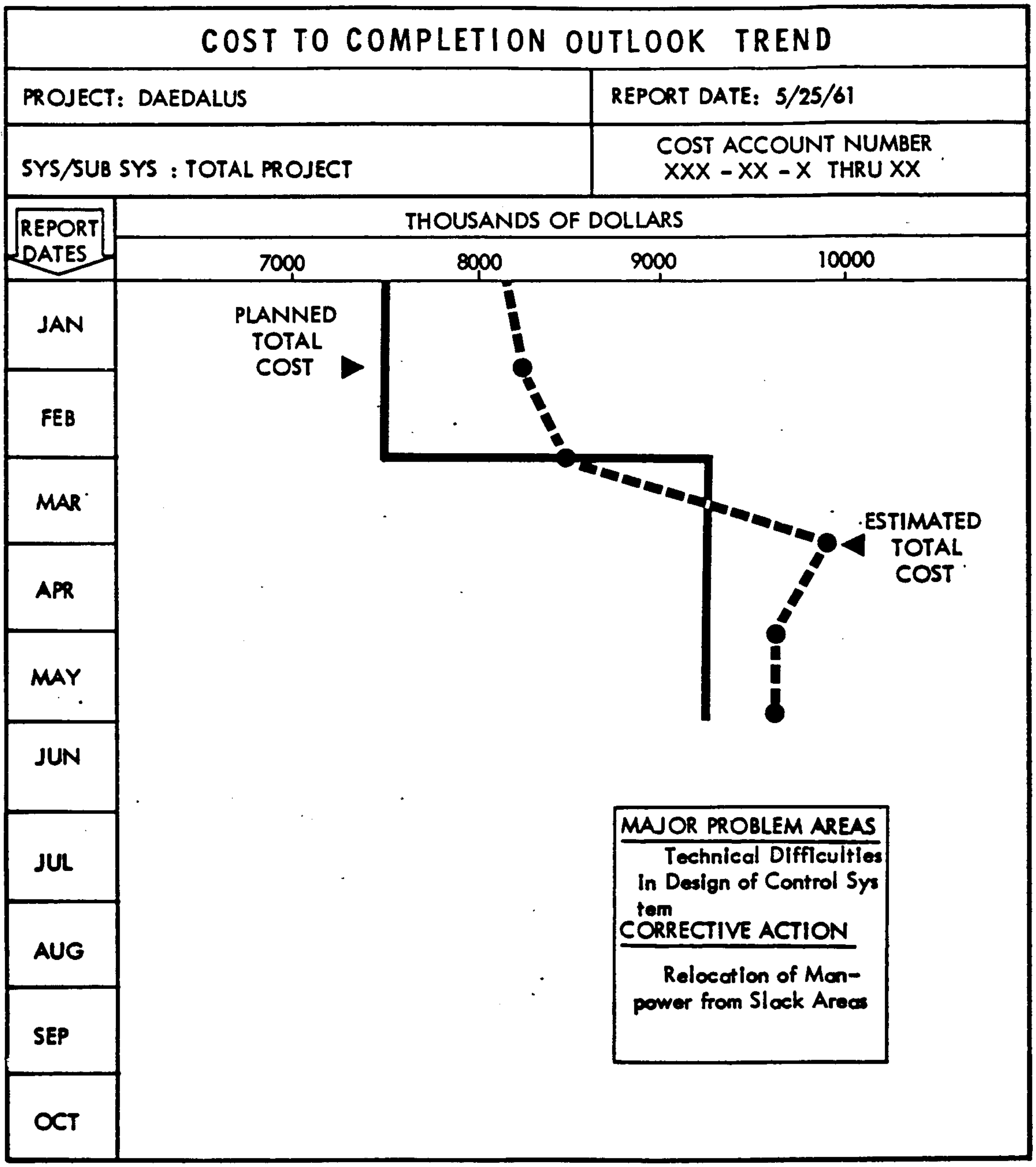

COST TO COMPLETION OUTLOOK TREND
PROJECT: DAEDALUS
REPORT DATE: 5/25/61
SYS/SUB SYS : TOTAL PROJECT
COST ACCOUNT NUMBER
XXX - XX - X THRU XX
REPORT DATES
THOUSANDS OF DOLLARS
7000
8000
9000
10000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
PLANNED TOTAL COST
ESTIMATED TOTAL COST
MAJOR PROBLEM AREAS
Technical Difficulties In Design of Control System
CORRECTIVE ACTION
Relocation of Manpower from Slack Areas

Fig. IX-c

A similar cost outlook trend is also developed as illustrated in Fig. IX-c. This type of cost trend is developed for the total project (as illustrated), each major contractor, NASA in-house effort, and finer breaks as necessary.

Outlook trends provide an excellent overall situation summary and provide an indication of areas that must be analyzed in further detail. In all cases, the reason for any change in outlook must be determined.

Critical Path Analysis

The critical path analysis is one of the most important elements of the NASA-PERT system and usually is done in conjunction with the quick look comparison. Each activity in the critical path should be reviewed by asking the following kinds of questions:

- Is the sequence of the activity in a "must" or "desired" order? If in a "desired" order, can the activity be sequenced in parallel with others in the critical path? If it can be sequenced in parallel with others, what added risk is being assumed and what is the effect on resource planning?

- Is the time estimate for the activity realistic? Can the time be shortened by adding resources? Does this decrease in time increase risk in meeting performance or reliability?

The same type of reasoning is applied to every path that has negative slack. If the project outlook indicates a possibility of accomplishment ahead of schedule (i.e., the critical path has positive slack) the critical path analysis becomes primarily an identification of the tasks that are controlling to ensure that they are given top priority and do not become negative.

Positive Slack Analysis

Analysis of slack in paths other than the critical paths is also important to ensure that the project is being executed in the most efficient manner. There is no point in using premium effort in an area where significant positive slack is indicated. If the positive slack is considerable one should consider the possibility of reducing the level of effort in that area and using the resources in more critical areas.

PERT/COST Comparative Analysis

Time/cost considerations are implicit in each of the analysis routines considered in previous paragraphs. In addition, a careful and complete analysis of cost data reported for each subdivision of work account in relation to the progress represented on the corresponding PERT fragnet is required. The extend of this analysis will vary from case to case and can best be illustrated by review of a case example.

Fig. IX-d shows the relationships that exist between a subdivision of work cost account, subsidiary elements of cost, and the associated PERT fragnet or portion of a fragnet. The relationship shows a time plan, cost plan, time progress and cost progress for a particular phase of the overall project. If all is going according to plan, it represents a somewhat static relationship between time and cost. When a deviation from the time or cost plan develops, an analysis of this data must be made to determine both the cause of the deviation and its effect on meeting the overall time and cost plan. For example, suppose the input data reported results in an expected date (T_E) for the end event which is later than the scheduled date (T_S). The same type questions that were asked in the critical path analysis would apply. If the schedule is to be maintained by increasing the level of effort, a corresponding change should be reflected in the cost estimate to completion. If the cost estimate to completion is not changed it would indicate that previous estimates were in error or that a corresponding decrease in the level of effort was made in another activity. If the latter is the case, then the time estimate for that activity should logically be increased. Similarly, any deviation in the cost plan should be reflected in the time plan.

Simulation

Analysis of a project in the manner prescribed in preceding paragraphs will often result in the determination of several alternate approaches that could be taken to remedy a problem or make more effective use of available resources. The flexibility and speed of the computer makes it possible to make several passes through the computer to simulate the effects of making each of the possible alternate decisions. The results can then be compared and analyzed before deciding which course of action should be taken.

Schedule Analysis

The general concepts of the master schedule and considerations in its preparation and modification have already been discussed in some detail in Section VIII. It is mentioned here primarily to re-emphasize that its review is an important step in the analysis process. It is also emphasized that the schedule analysis should not be limited to the key objectives. The introduction of the PERT technique has placed a significant amount of emphasis on the effect of today's progress on meeting key end objectives but does not force this same degree of emphasis on the intermediate milestones. It is well to remember that the length of time it takes to do a job is often influenced by the length of time available to do it. Consequently, significant and realistic schedules for intermediate events play an important role in the timely execution of the overall project.

PRESENTATION TO MANAGEMENT

In general, management is interested in information that answers the following kind of questions:

533/PERT COMPARATIVE ANALYSIS

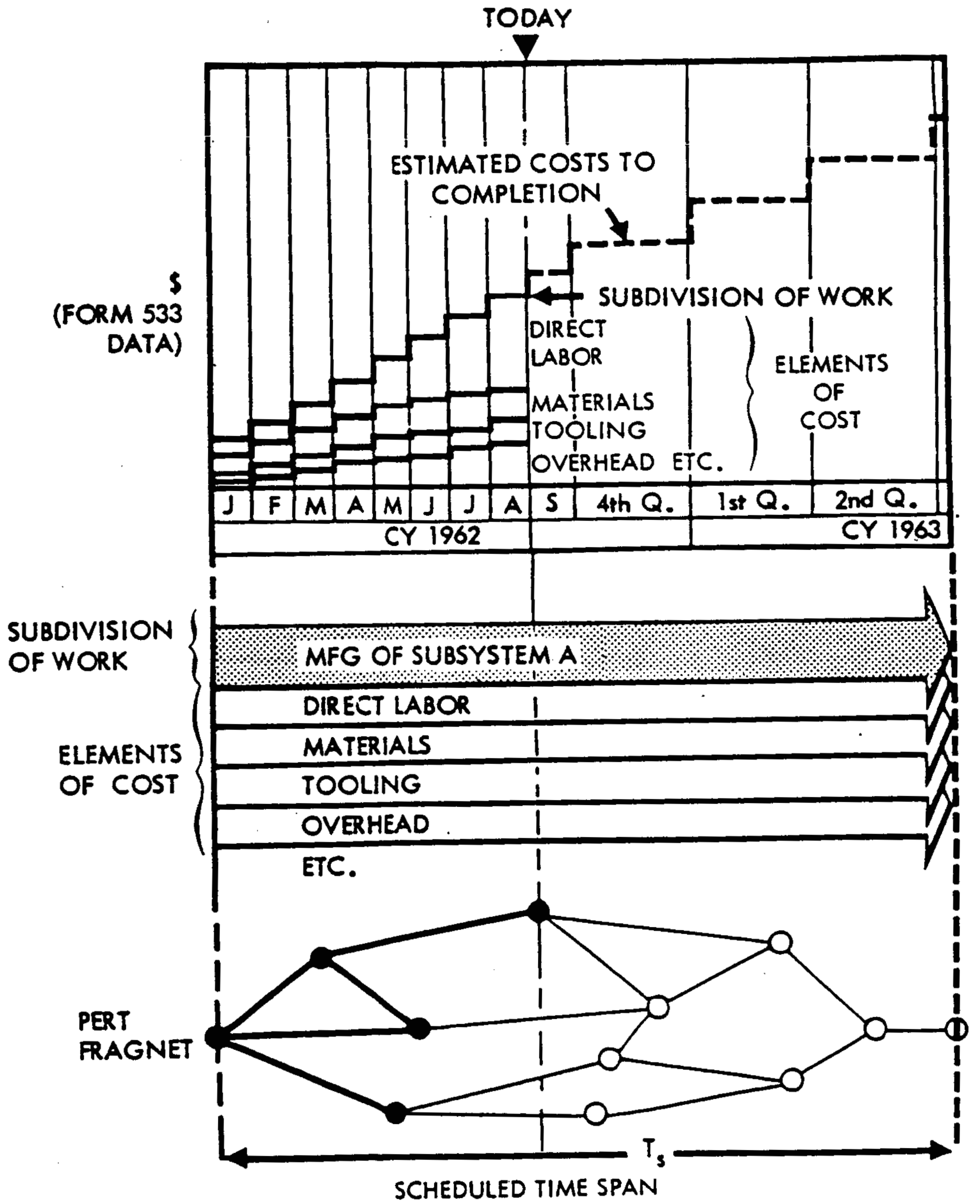


Fig. IX-d

- Is the project meeting the committed schedule and cost estimates and, if not, the extent of any difference?
- If the outlook for meeting the committed schedule and cost estimates improving or getting worse and, why?
- What progress is being made?
- Have manpower and other resources been planned realistically to minimize premium costs and idle time?
- What problems are being encountered? What corrective action has been initiated and what is the anticipated effect of this action on time schedules and cost estimates?
- Can manpower and other resources be shifted to expedite critical activities?
- What are your recommendations, if any, for action on the part of higher levels of management?

The NASA-PERT and Companion Cost System can provide answers to all these questions. However, it is generally agreed that the format of the PERT network and the cost data is not the best presentation to management. The data must be converted into a format that is easily understood and communicates the information to be presented. A considerable variety of presentation techniques has been developed. Unfortunately, no one technique provides the answer to all operational situations that arise, and special presentations must often be prepared. However, operational experience has indicated that the time and cost outlook trend charts, master schedules and master cost plans already discussed in previous sections provide a useful set of standard presentations that should be maintained for all projects. These standard presentations are tied together by a supporting narrative analysis as outlined in Fig. IX-e. As a readily available summary of the data on which the narrative analysis is based, Fig. IX-f is often prepared as an attachment to the analysis. The use of this or similar purpose documents is not required by this handbook but is left to the option of the NASA project manager.

MANAGEMENT DECISION

The NASA-PERT and Companion Cost System does not guarantee infallible planning, nor does it make management decisions. However, it does provide a significant amount of comprehensive information upon which management can base its decisions. The system does not provide absolute answers and predictions but it does give relative magnitude to problems.

As previously mentioned, the system also provides the capability of testing the potential impact of various alternate courses of action prior to making a recommendation for management decision.

NARRATIVE ANALYSIS FORMAT

SUMMARY OUTLOOK

A short statement summarizing the current cost and time status in relation to plan as well as the outlook for achieving major goals with anticipated resource requirements. This statement should include a reference to the status reported previously and a brief explanation for any change in outlook or anticipated resource requirements.

STATUS VS. PLANS

Significant Progress

A concise statement of significant progress during the report period. In general, this discussion should be addressed to accomplishment of key milestones on the master schedule.

Problem Areas

An identification and discussion of the critical path(s) as derived from the latest computer output and their resources implications, if any.

This section should also include an indication of any technical problems that have been encountered and a discussion of any significant deviations in the cost plan that may have developed.

Change in Plans

An indication of corrective action which has been taken and the anticipated effect on resources.

RECOMMENDATIONS

Recommendations for action on the part of higher levels of management.

Fig. IX-e

NASA PERT AND COMPANION COST

REVISE MASTER PLANS

The last step in the analysis and management action cycle shown on Fig. IX-a is to revise the master plans to reflect the management decisions which have been made. The techniques and procedures for reflecting these changes in the master plans a.e discussed in detail in Section VIII.

NASA PERT & COMPANION COST MANAGEMENT SUMMARY REPORT	PROJECT: DAEDALUS	REPORT COVERS THE PERIOD FROM: JULY 1961	TO: MAY 1962
	NAME OF CONTRACTOR/PERFORMING ORGANIZATION: VARIOUS	CONTRACT NUMBER/SYSTEM CODE: VARIOUS	SUMMARY LEVEL: TOTAL PROJECT

COSTS IN: THOUSANDS

E - Earliest completion date
S - Scheduled completion date
L - Latest completion date

WORK BREAKDOWN	COSTS TO DATE PLAN	COSTS TO DATE ACTUAL	COSTS TO DATE OVER (Under)	AT COMPLETION PLAN	AT COMPLETION LATEST REVISED ESTIMATE	AT COMPLETION PROJECTED OVERRUN (Underrun)	1963 J A S	1963 O N D	1964 J F M	1964 A M J	1964 J A S	1964 O N D	1965 J F M	1965 A M J	1965 J A S	1965 O N D	DAY	SLACK (Weeks)
Total Project	800	983	183	9240	9665	425						L S	E				27 15	- 6.3
Experiments	50	38	(12)	700	700	—		E S	L								17 15	+ 17.6
Spacecraft Structures	110	160	50	900	950	50		E	S L								15 15	+ 8.6
Spacecraft Power	—	—	—	390	390	—	E	S	L								30 15	+ 19.4
Control & Stabilization	550	695	145	2000	2375	375			S L	E							29 15	- 6.3
Telemetry	90	90	—	600	600	—			E S L								15 15	+ 4.3
Integration & Test	—	—	—	1500	1500	—					S L	E					27 15	- 6.3
Launch Vehicle	—	—	—	2000	2000	—					E S L						12 17	+ 4.9
Launch Operations	—	—	—	390	390	—						L S	E				27 15	- 6.3
Data Acquisition	—	—	—	760	760	—						E S L					13 15	+ 4.7

REMARKS

Fig. IX-f

APPENDIX A

GLOSSARY

Accrued costs

Costs of goods and services used to accomplish the assigned work regardless of when received or paid.

Activity

An event is separated from other events by activities. An activity is a time consuming element in the development process. It is represented on a network by an arrow. An activity cannot be started until its preceding event has been accomplished. A succeeding event to an activity cannot be accomplished until the activity is complete.

Activity time

Estimate of the time necessary to complete an activity in a specified manner. This time is specified in weeks and tenths of weeks.

Cost estimate to completion

The estimate of resources required to complete an element of work based exclusively on consideration of the work remaining to be accomplished. Under no circumstance should this figure be derived by subtracting the actuals to date from the total estimate.

Costs

The amount or equivalent paid, given or charged, or engaged to be paid or given, for anything; whatever is requisite to secure benefit.

Critical path or pacing path

The particular sequence of activities in a network that comprise the most rigorous time constraint in the accomplishment of the end event. The path with the smallest amount of positive slack or largest amount of negative slack.

Element of cost

An object, thing, or service (used to accomplish work) classified by its characteristics rather than by the end purpose which it serves. In NASA PERT it is a break within a subdivision of work for which financial data is collected, e.g., direct labor, material, overhead, subcontracting, tooling, etc.

End item subdivision

A definable and recognizable piece of hardware, a service, an equipment or facility that is delivered to the government or made or performed in-house.

Event

A meaningful specified accomplishment in the plan recognizable as a particular instant in time. (The boxes on a network.)

Flight mission (or mission)

Within a project, the specific scientific or technical objective(s) to be accomplished by a given launching of a space vehicle or launch vehicle.

Fragnet

A portion of a project network involving the efforts of a single contractor, agency, or field center or subdivision thereof on a particular project. A single contractor's efforts on a particular project may be represented by more than one fragnet.

Functional work package

A functional break within an end item subdivision, e.g., design, manufacture, testing.

Interface

An interface defines the relationship that exists between various areas of work effort. The interface ties together the events and activities within one area of work effort that constrain completion of events and activities within another area of work effort. Interfaces exist between the gross areas of work effort as defined by individual fragnets as well as between areas of work effort within the fragnet.

Manager

The individual in the field center who is assigned the operational responsibility for executing to completion the development and operation of a project, a system, or a flight mission. (Project manager, system manager, flight mission manager.)

Negative slack

The amount of time which is not available to perform the series of activities in a particular slack path and still meet the required completion date.

Network (logic network)

A flow plan consisting of all the activities and events that must be accomplished to reach the network objectives, showing the sequences in which they are planned to be accomplished and their interdependencies and interrelationships.

Official NASA Flight Schedule

A compilation of all major NASA launch dates. For each project, launch dates are set at the time of project approval by the Associate Administrator and his approval is required to change them. The flight schedule is reviewed and updated with approved changes monthly.

Planning network

In PERT, a logic network developed during the early planning phase at a gross level of detail to give subsequent detailed planning a disciplined approach. By this method, a gross assessment of alternative approaches, associated deadlines, and rates of funding buildup can be established. Generally, this type network is not adequate for management control and is supplanted by more detailed control networks as soon as possible.

Positive slack

The amount of additional time which is available to perform the series of activities in a particular slack path and still meet the required completion date.

Preceding event

See Activity.

Program

A related series of undertakings (projects) which are funded for the most part from NASA's Research, Development, and Operation appropriation, which continues over a period of time (normally years), and which are designed to accomplish a broad scientific or technical goal in the NASA long range plan.

Program chief

The staff individual in Headquarters to whom a Headquarters Program Director has assigned cognizance over a program.

Program Management Plan (PMP)

A series of charts keyed to a work breakdown structure of a program on which are listed key events (milestones) and associated schedule dates.

Project

Within a program, an undertaking with a scheduled beginning and ending which normally involves one of the following primary purposes:

(1) The design, development and demonstration of major advanced hardware items;

(2) The design, construction and operation of a new launch vehicle (and associated spacecraft and ground support) during its research and development phase; or

(3) The construction and operation of one or more space vehicles and necessary ground support in order to accomplish a scientific or technical objective in space; or

(4) The development and construction of a major facility including necessary equipment and instrumentation.

Project network

A complete network for a project including the efforts of all participating contractors, agencies and NASA field centers; a collection of associated and interconnected fragnets.

Request for Proposal (RFP sometimes referred to as RFQ, Request for Quotation

The official document which requests from prospective contractors—industrial, universities, or other government agencies, a description of the manner in which they would achieve the objective specified by the RFP if they were awarded a contract to do so. This plan normally includes the proposer's estimate of total cost and required schedule.

Subdivision of work

A major work package which serves as the basic unit for correlating financial data to the time plan representing that work package on the PERT fragnet.

Subsystem

Name for the next level of a work breakdown structure under system.

Subtask

Name for the next level of a work breakdown structure under task.

Succeeding event

See Activity.

System

One of the principal functioning entities comprising the project hardware within a project or flight mission. The terminology may vary to suit a particular project. Ordinarily, a "system" is the first major subdivision of project work. (Similarly, a "subsystem" is a functional entity within a system.)

Task

Name for the next level of a work breakdown structure under subsystem.

Time estimate

As used in NASA PERT and recorded on NASA form 577 it is a single estimate of the time required to complete an activity as would reasonably be expected by the person best qualified to judge.

Work breakdown structure

A family tree subdivision of the work required to be accomplished to achieve an objective. For a project, the work breakdown structure is developed by starting with the end objectives of the project and then successively subdividing these objectives into the systems, subsystems, tasks and subtasks (etc.) which are the necessary steps to achieve the end objective.

Work packages

The unit of work required to complete a specific job such as a report, a design, a drawing, a piece of hardware, or a service which is within the responsibility of one operating unit in an organization..

APPENDIX B

BASIC PERT DESCRIPTION

NETWORK CONCEPT

PERT employs a network as a logic diagram or flow chart. A simple PERT network is illustrated in Fig. B-1. Each arrow or activity in this network represents one of the various planned tasks or jobs leading to the end objective and requires expenditure of resources such as time, labor, and material.

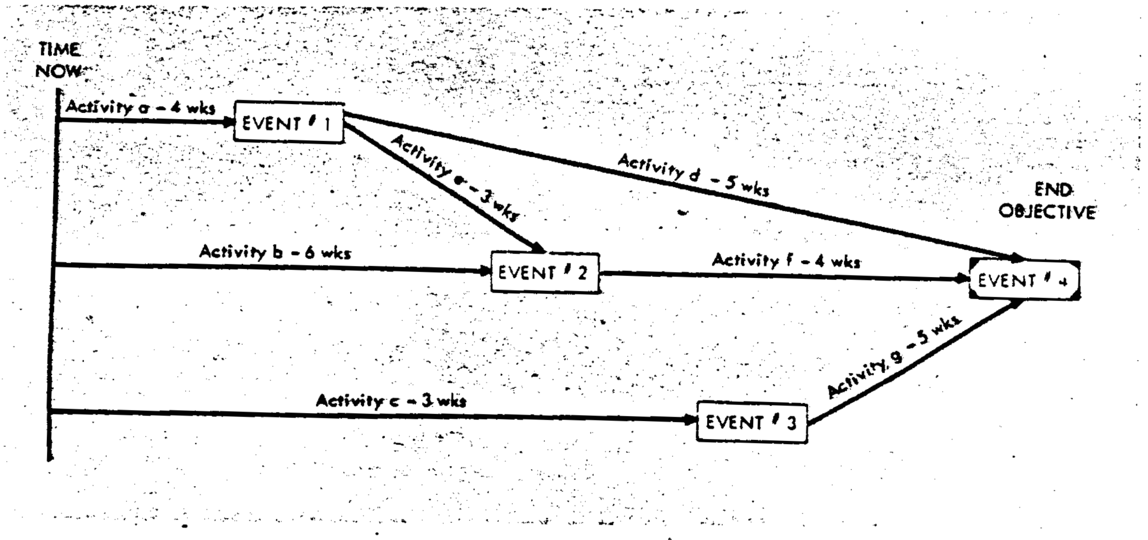


Fig. B - 1

The squares at the beginning and end of the activity arrows in Fig. B-1 are events or milestones in the PERT network. An event is a definable point in time and signifies a decision to start or terminate an activity or job. An event, unlike an activity, does not require the expenditure of resources. An event is used, for example, to identify the point in time at which funds are released, a contract awarded or an item delivered.

The discipline followed in constructing a PERT diagram results in a dependent sequence network. This network indicates the interrelationships and constraints in the plan. After the network activity and event relationships are developed, the time required to accomplish each activity is estimated and noted on the network. For example, in Fig. B-1, it has been estimated that activity "a" will require four weeks, activity "b" six weeks, etc. Each activity must be accompanied by a time estimate in order to make proper use of the network in accordance with PERT procedures.

EXPECTED EVENT COMPLETION DATES

- The usefulness of the dependent sequence network can best be demonstrated by an example. Consider the network in Fig. B-2.

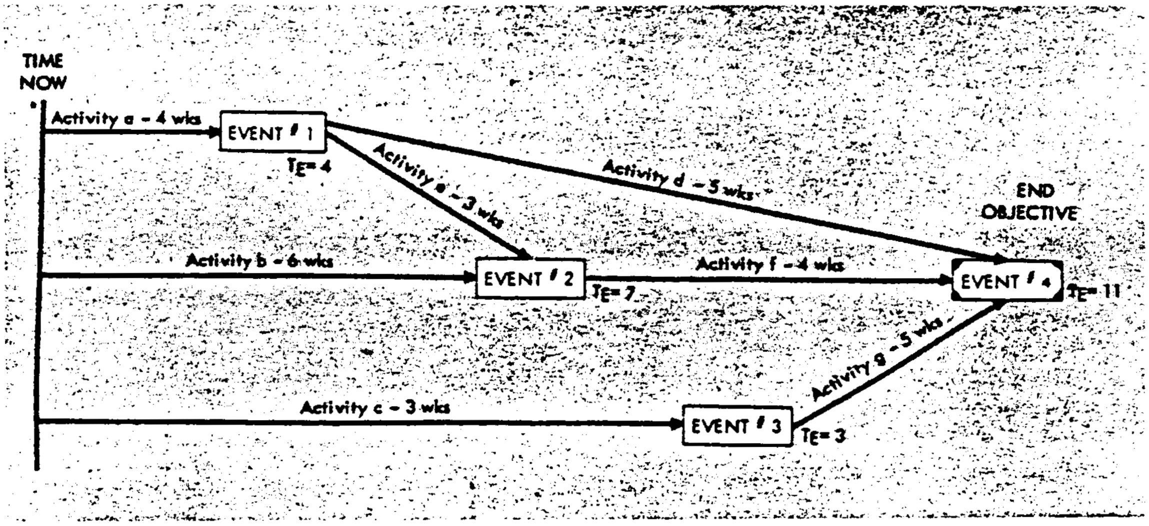


Fig. B - 2

In this example:

- Activities a, b, and c can be started simultaneously.
- Activity f cannot be started until after activities b and e have been completed.
- The time to accomplish activity a is four weeks, activity b is six weeks, activity e is three weeks, activity f is four weeks and activity g is five weeks.

The computer, starting from "time now", calculates the earliest date (T_E) by which each event could be expected to be completed. For example, activity a is expected to take four weeks; therefore, event #1 could be accomplished in four weeks. In the case of event #2, both tasks b and e must be completed before event #2 is accomplished, and T_E here is seven weeks. T_E for the end objective, event #4, is eleven weeks. Therefore, the computer selects the longest path up to each event in its calculation of T_E. Fig. B-2 shows the T_Es as they would be calculated for this simple network. All of the times in Fig. B-2 are expressed in weeks from "time now". In the generation of computer printouts these times are converted to calendar dates.

LATEST ALLOWABLE DATE AND SLACK

Once T_E = 11 weeks has been determined, latest allowable time, T_L, by which each activity must be accomplished if event #4 is not to occur more than eleven weeks after "time now", can be calculated. This is accomplished by starting at the end objective where T_L = T_E = 11 and successively subtracting the activity time estimates in reverse sequence. For example, if it takes five weeks to accomplish activity g, then event #3 need only be completed five weeks earlier than the eleven week T_L for event #4. In other words, the T_L for event #3 is six weeks from "time now". The previous T_E calculation for event #3 indicated that event #3 was expected to be completed in three weeks from "time now". Consequently, the accomplishment of event #3 could be delayed by three weeks without jeopardizing meeting the expected date for the end objective. This difference or cushion is called slack (S) and is equal to T_L minus T_E.

If we insert the latest allowable date, T_L, and slack (S) along with the expected date, T_E, on the network for each event we have the result shown in Fig. B-3. Notice that a zero slack path has been identified through events 1, 2, and 4 (dotted lines). This is the longest or critical path on the network. The activities and events on this path effectively establish and control the time to reach the end objective, event #4. There is no cushion or slack on this path and slippage of any event will reflect as an equal slip in the end objective.

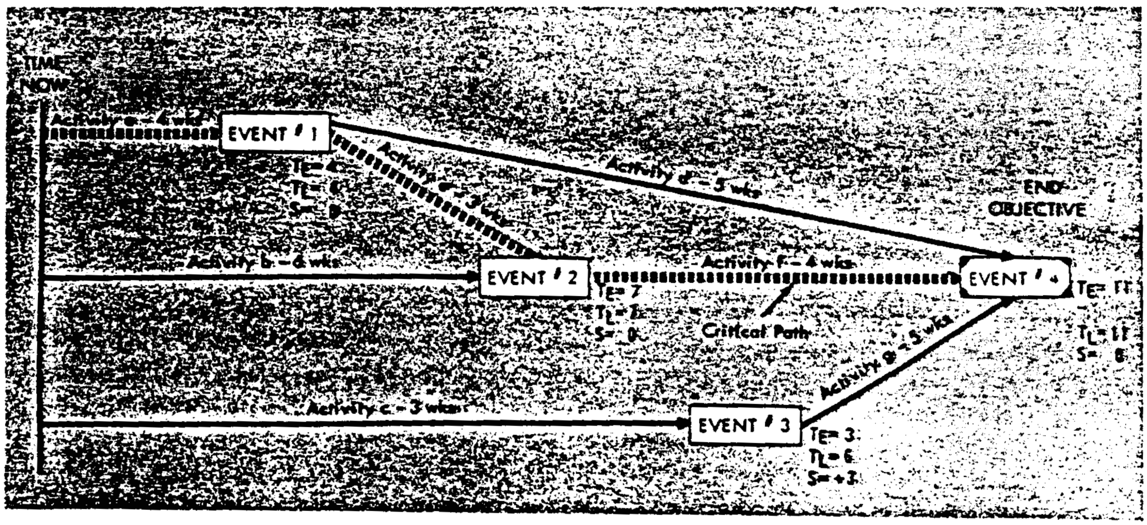


Fig. B - 3

USE OF SCHEDULE DATES

Suppose now that a scheduled target date, T_S, for accomplishment of the end objective, event #4, is only nine weeks from "time now". In this case the T_L for the end objective is equated to the scheduled date, T_S, rather than the expected date, T_E, as illustrated in the previous example. The computer then calculates the latest allowable date, T_L, for the accomplishment of all other events to support the scheduled date, T_S, for the end objective. For example, if it takes five weeks to accomplish activity g, then event #3 need only be completed five weeks earlier than the nine week T_S for event #4. In other words, the T_L for event #3 is four weeks from "time now". The previous T_E calculation for event #3 is four weeks from "time now". The previous T_E calculation for event #3 was expected to be completed in three weeks from "time now". Consequently, the accomplishment of event #3 could be delayed by one week without jeopardizing meeting the scheduled date for the end objective. The results obtained when the scheduled target date for event #4 is nine weeks from "time now" are illustrated in Fig. B-4.

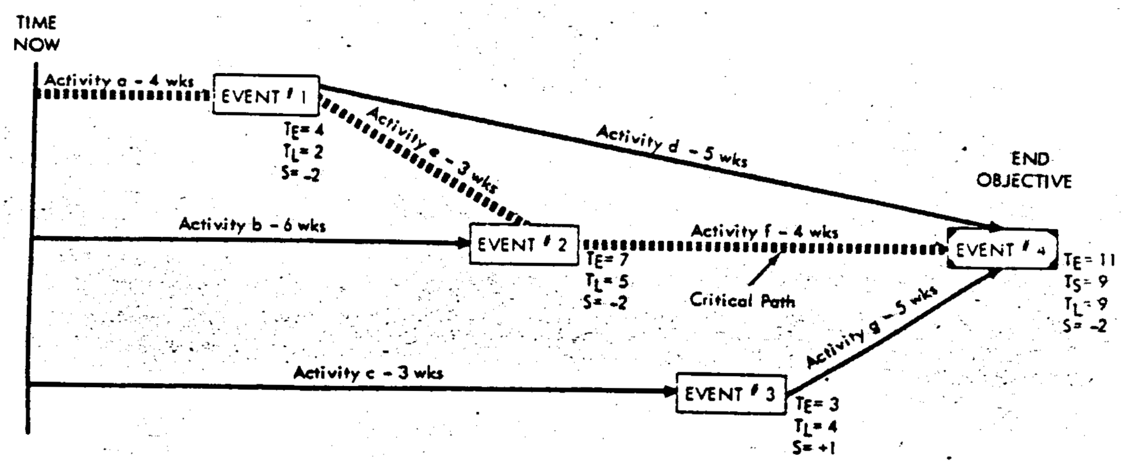


Fig. B - 4

Notice in Fig. B-4 that events 1, 2, and 4 now each have a negative slack of two weeks. This indicates that the chain of activities (time now - 1-2-4) is pacing and must be reduced by two weeks in this case if the scheduled date for the end objective is to be met. Several different courses of action could then be taken:

- Consider the effect of using additional resources on the tasks in the pacing paths.
- Consider alternate approaches such as parallel efforts which may involve greater risk.
- Consider the effects of relaxing performance requirements.
- Acknowledge a probable slip in meeting the end objective.

Conversely, if large amounts of positive slack are indicated, consideration should be given to decreasing the level of effort in those areas or diverting effort to more critical areas.

Obviously, a computer is not needed for such simple networks as used here. However, experience by Government and Industry has demonstrated that the computer can serve as a significant aid to the Project Manager in directing complex development projects.

NETWORK DEVELOPMENT

Since the network is the key element of the NASA-PERT System, it follows that the quality and validity of the computer outputs are dependent on the quality and validity of the network. Consequently, the development of the network should entail careful consideration of the activities required to meet the end objective, their interrelationships, and the time required to complete them.

Network development is best done as team effort. Members of the team should include technical people responsible for major elements of the project, at least one expert in the use of the system, and representatives of the planning staff. The network should be developed jointly, i.e., each member should make his inputs in the presence of the other members. This has been found to be a most effective way of pinning down responsibilities. It also fosters an exchange of ideas which gives each member a better feel for the project as a whole.

The best approach in developing the network has been found to be the "back to front" approach. That is, start with the end objective and work toward the beginning. Starting with the end event, a survey should be made among the team members to determine all of the "must" activities that must be completed before the event can be considered to be achieved. These activities then should be represented on the network as shown in Fig. B-1. Activities d, f, and g on Fig. B-1 must be completed before the end objective can be achieved. Each preceding event is treated in the same way. Event #2, for instance, is not complete until activities b and c are completed. Conversely, activity f cannot be started until Event #2 is achieved. This procedure is followed until a total network is developed. It must be emphasized that all possible constraints for each milestone should be included. In certain instances these constraints may not actually represent tasks to be done, but rather a dependency on completion of another activity, possibly due to manpower or facility limitations. Such a constraint can be shown on the network as an arrow with a zero time estimate connecting the pertinent milestones.

TIME ESTIMATING

The next step is to add the time estimate to each activity. The time estimate should be made by people most familiar with the job and should not be arbitrarily selected to balance the network to make it coincide with a previously specified scheduled date. Reference to calendar dates should be avoided when time estimates are being made.

Each activity should be considered separately when making time estimates, and the estimates should be in weeks and tenths of a week. Each time estimate should be the best estimate available, based on all known factors of how long it will take to complete the activity under normal conditions. As the project progresses, the estimates should be continually reviewed and changed where applicable to take advantage of actual operating experience (learning curves) and to adjust to changing conditions. Obviously, the quality of the time estimates depends substantially on the background and experience of the estimator.

APPENDIX C

TWX REPORTING PROCEDURE

The commercial TWX network operated by AT&T represents an efficient and timely method of transmitting NASA-PERT data. As a general rule, however, this type of reporting is subject to an increased rate of error and it is, therefore, recommended only for biweekly updating or minor network revision. When establishing a new network or performing a major revision to an existing network, it is recommended that NASA Form 577 be used for reporting. Under any circumstance, the following procedures should be used only when there has been prior agreement between the sender and the receiver of the PERT report.

When the NASA Project Manager decides that TWX reporting should be instituted, the following steps should be followed:

Step 1 - Place a TWX call to the NASA Computer Processing Center. (The exact location and TWX call code will be furnished by the NASA Project Manager.

Step 2 - Transmit message heading which should include:

(a) Date time group
(b) Originating Activity
(c) Action Activity (NASA Field Center by whom your contract was awarded)

Step 3 - Ensure that NASA Computer Processing Center has a reperforator on the circuit as they may use the punched paper tape to produce computer input. (This capability does not remove the requirement for a review by the NASA Project Staff of the updating information prior to computer processing.)

Step 4 - Transmit:

(a) Your reference number (if any)
(b) Network title (limit - 60 characters)
(c) PERT report date
(d) Network start date
(e) Network number (2 alphabetic and/or numeric characters)
(f) Ten letter Z's, carriage return and line feed

Step 5 - Transmit detailed activity data as follows:

(a) 3-digit line number
(b) One space
(c) Transaction codes as follows:

1 - Establish new activity
2 - Re-estimate activity
3 - Complete activity
5 - Remove from Network

(d) One space
(e) Master schedule flag (2 digits)
(f) One space
(g) Seven-digit predecessor event number
(h) One space
(i) Seven-digit successor event number
(j) One space
(k) Four-digit time estimate in weeks and tenths of weeks (decimal point assumed)
(l) One space
(m) Four-digit resource estimate
(n) One space
(o) Six-digit schedule or actual date
(p) Carriage return and line feed
(q) Three-digit line number
(r) Space
(s) Activity description (up to 43 alphabetic and/or numeric characters
(t) Space; dollar sign, space
(u) Four character organization code
(v) Carriage return and two line feeds
(w) If a mistake is noted while typing a line, give a carriage return, type three X's over the line number, give another carriage return and a line feed. If it is necessary to correct a line that has been completed, wait until all other lines have been typed, then space one line and type "CORRECTIONS", carriage return and line feed; then using the format in step 5 (a) through (v) type the corrected line(s).
(x) After all activity data and corrections have been transmitted, type ten letter Z's, carriage return, and line feed. (At this point the message may be ended if there are no remarks to be sent.)

NOTE: If it is desired to omit information required in steps (e), (k), (m), or (p) an appropriate number of zeros should be entered.

Step 6 - Transmit any remarks as follows:

(a) Type "REMARKS", carriage return and line feed.
(b) Start each remark with two, three-digit line numbers used in step 5 to identify the activity with which the remark is associated.

Step 7 - Name of person sending message.

Step 8 - TWX Operator sign off.

NASA PERT AND COMPANION COST

EXAMPLE

TWX

182043Z AUG

FROM XYZ COMPANY, NEW YORK, NY
TO LANGLEY RESEARCH CENTER, HAMPTON, VA

DAEDALUS PROJECT OFFICE SENDS X THE FOLLOWING IS TO BE RECEIVED ON PUNCHED PAPER TAPE X LRC ARE YOU READY X

DE LRC X RR X GA WITH MSG

IN REPLY REFER TO XYZ MESSAGE NUMBER 123-456 X POWER SUPPLY SUBSYSTEM, PROJECT DAEDALUS X PERT REPORT TO 08 17 62 X NETWORK START DATE IS 04-15-61 X NUMBER F9 X

ZZZZZZZZZZ

001 2 00 1112345 1112346 0040 0320 000000
002 ESSENTIAL PROCUREMENT NEGOTIATION $ XYZ9

003 2 00 1112346 1112349 0400 0320 000000
004 PROCUREMENT PAPERWORK PROCESSING $ SP11

~~005~~ 1 01 1112756 1112577 0000 0000

005 1 01 1112756 1112757 0000 0000 071063
006 FINAL REPORT SUBMITTED $ CR01

CORRECTIONS
003 1 00 1112346 1112349 0040 0000 000000 0097

ZZZZZZZZZZ

REMARKS
001 002 ESSENTIAL PROCUREMENT REFERS TO THOSE SUBSYSTEMS INTENDED TO FLY IN THE PROTOTYPE SPACECRAFT

R JONES X
9:27 AM 08 18 62 PLS ACK ONE MSG AND THX

DE LRC X QSL UR 182043Z AT 202039Z

Fig. C - 1

APPENDIX D

PROCUREMENT CONSIDERATIONS

The NASA PERT and Companion Cost System has two major interfaces with the NASA procurement process—the request for proposal and the contract. When preparing either of these documents certain considerations must be given to the government requirement for management information.

When it has been decided to use the NASA PERT and Companion Cost System in the proposal evaluation process, the prospective contractors should be so notified by including in the proposal solicitations the standard clause contained in NASA procurement regulations (Chapter 18 of the NASA General Management Instructions). In addition, the following items should be attached to the RFP to ensure understanding by the prospective contractors:

- A copy of the contract clause
- The preliminary work breakdown structure with a clear indication of what parts of the total job are covered by the solicitation
- The master schedule with milestones applicable to the solicited work highlighted
- A copy of the NASA PERT and Companion Cost System Handbook

A standard set of clauses for incorporating the NASA PERT and Companion Cost System requirements, along with regulations governing their usage, are also included in the NASA Procurement Regulations.

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